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PHYSICAL
GEOGRAPHY

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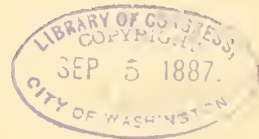
UNITED STATES OF AMERICA.



BUTLER'S GEOGRAPHICAL SERIES

BUTLER'S PHYSICAL GEOGRAPHY

BY JACQUES W^{ord here!} REDWAY.



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PREFACE.

THE great advances made in geographical research during the past few years have placed Physical Geography among the essential studies.

The volume which the publishers herewith present embraces the latest discoveries in geographical science. In the chapters on Vulcanology, Ocean Hydrography, and Meteorology, there is much new material which has never before appeared in a school text-book.

The contents have been so arranged that the leading principles are found in the text, while other relevant matter of instructive nature has been placed in the notes. By this arrangement clearness of statement has been obtained, which makes the volume adaptable to schools of all grades.

Acknowledgments are due to the U. S. Coast and Geodetic Survey, the U. S. Geological Survey, and the U. S. Hydrographic Office, for valuable information.



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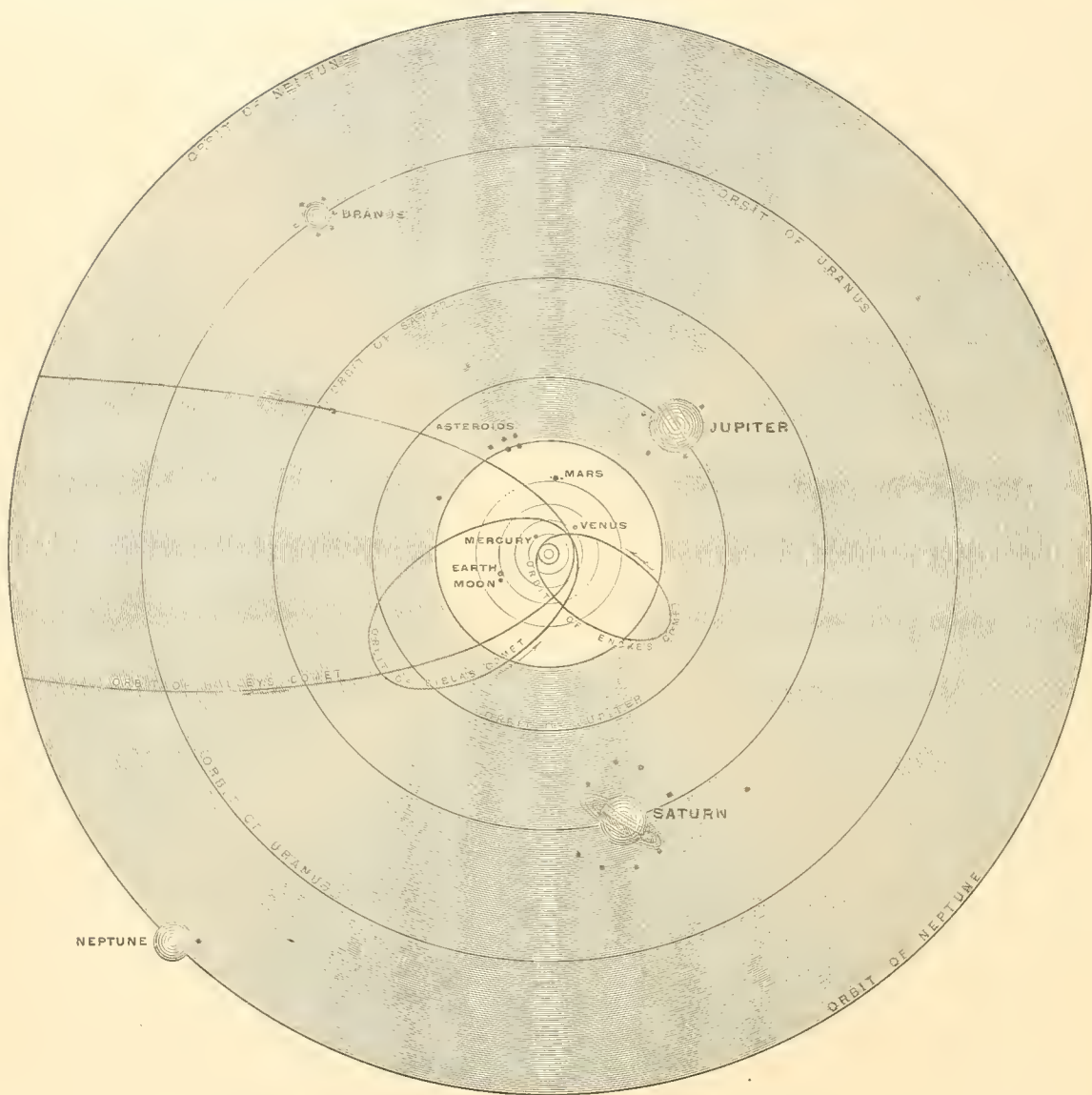
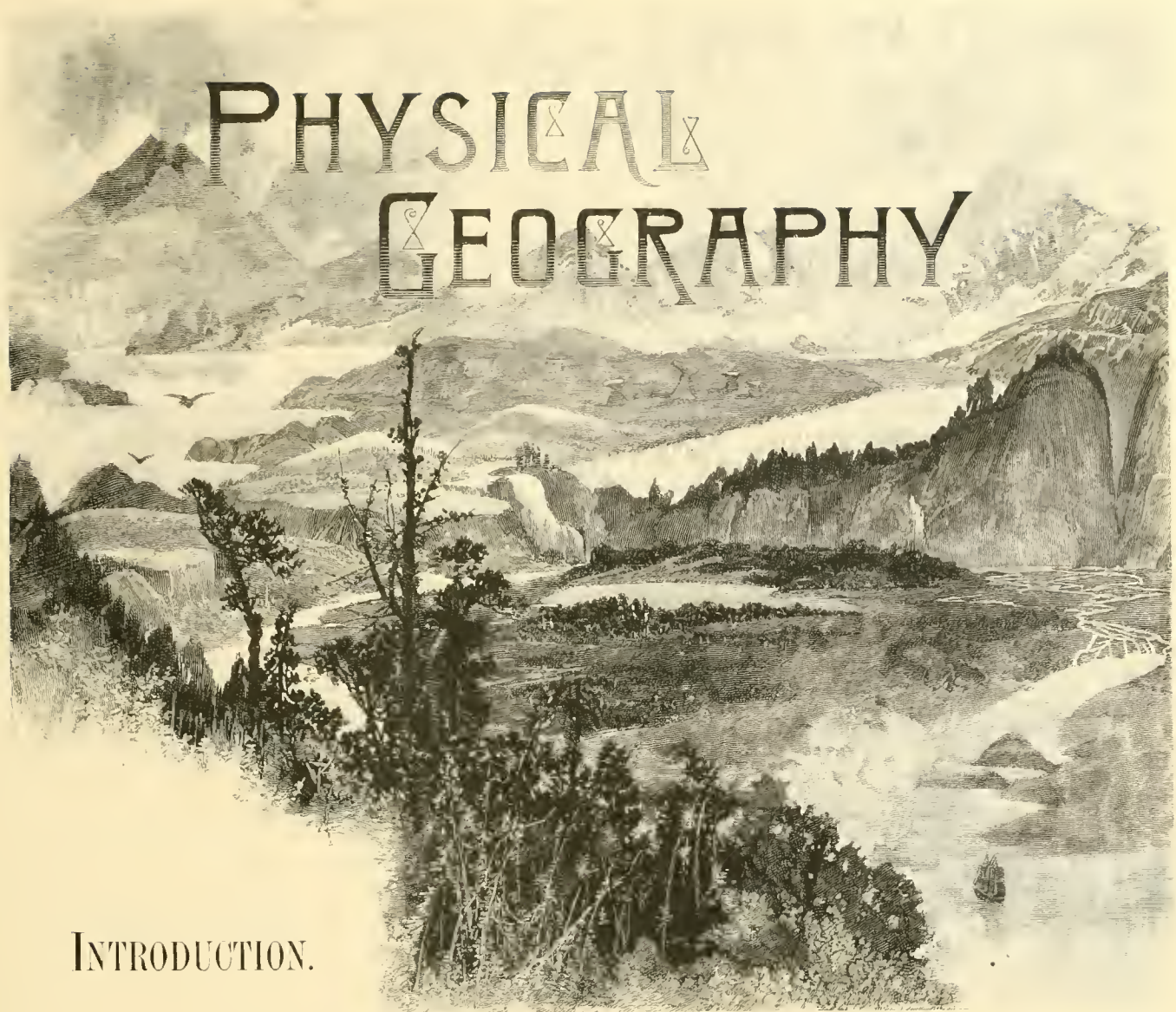


DIAGRAM OF THE SOLAR SYSTEM.

[THE SPACE WITHIN THE ORBIT OF SATURN SHOWS THE PROPORTIONATE SIZE OF THE SUN.]



PHYSICAL GEOGRAPHY

INTRODUCTION.

DURING past ages the surface of the Earth has undergone many and great modifications, and the same agents which then wrought are still actively at work.

Physical Geography, or Physiography, is the science which treats of the surface of the Earth and the manner in which it has been changed by the forces of nature.

The outlines of this science are not closely defined, and the following chapters treat not only of those subjects which are properly included in the study of Physical Geography, but also of certain principles which are common to Astronomy, Geology, and Meteorology.

As considered in this volume, Physical Geography is embraced under the following divisions:

- I. THE EARTH REGARDED AS A PLANET.
- II. THE STRUCTURE AND FORMATION OF THE EARTH.
- III. THE LAND.
- IV. THE WATER.
- V. THE ATMOSPHERE AND ITS PHENOMENA; OR, METEOROLOGY.
- VI. THE DISTRIBUTION OF LIFE.

PART ONE.

THE EARTH REGARDED AS A PLANET.

CHAPTER I.

1. **The Earth** is a planet,¹ and, so far as known, it is the third in order of distance from the sun.

2. **Form of the Earth.**—To an observer who stands on an elevated position, the earth seems to be an immense plain diversified with mountains and valleys, and, for the greater part, covered with a vast expanse of water. The apparent flatness is an illusion, for various experiments prove beyond doubt that the earth has a globular form.

i. When a vessel approaches land, the topmasts are first seen, then the lower sails appear, and finally the hull of the vessel comes into view.²



THE CURVATURE OF THE EARTH'S SURFACE.

ii. Navigators sailing in a given general direction have at length reached the ports from which they sailed. This has been accomplished repeatedly.

iii. The visible portion of the earth's surface is always circular. For instance, if a slice be cut from a spherical body, as an orange, the rounded surface of the slice will represent that part of the earth which is seen by the observer. The *bounding line* of this surface is the *circumference of a circle*. If the slice be cut from an oval body, as a lemon, the bounding line will not always be the circumference of a circle, but usually that of an *ellipse*.

iv. The shadow of the earth which is projected on the moon during a lunar eclipse is always a circle. No solid except a sphere will always project a circular shadow.

Although the earth is globular in form, it is not a perfect sphere. If it were a perfect sphere, the length of a degree, angular measure, would be the same at all parts of its surface. Careful measurements show, on the contrary, that the length of the degree varies, being somewhat greater at the poles than near the equator. From this and from other observations, it has been shown that the earth is slightly flattened at the poles—a form to which the name *oblate spheroid*³ is given.

3. **Size of the Earth.**—According to recent measurements, the equatorial diameter of the earth is 7925.6 miles,⁴ and the polar

diameter, 7899.2 miles—a difference of 26.4 miles. The circumference of the earth at the equator is 24,899 miles. The surface of the earth is about 197,000,000 square miles in area; its volume is about 260,000,000,000 cubic miles. Compared with the sun, the earth is about $\frac{1}{1,250,000}$ its size.

4. **Density.**—The density of the whole earth is five times that of water. At the surface, however, the density is only two and a half times that of water. It is inferred from this that the interior of the earth consists largely of metallic substances.

5. **Axis of the Earth.**—The axis of the earth is the line about which it spins or rotates. This line is also the polar diameter. The northern extremity of the axis is called the *north pole*; its southern extremity, the *south pole*.

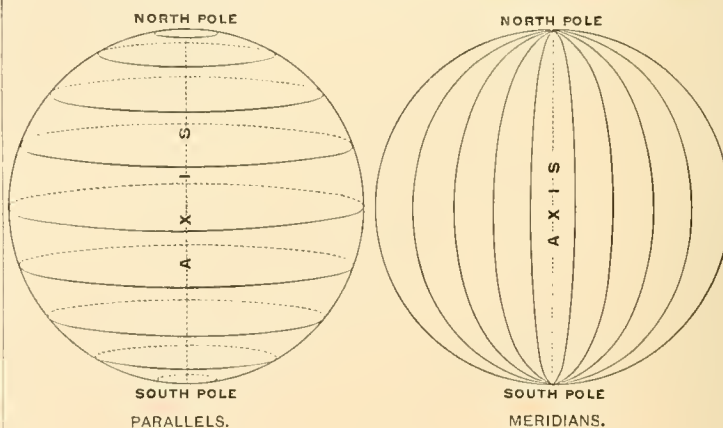
The position of the earth's axis determines that of each of the other imaginary lines.

6. **Circles.**—In order to describe the positions of places, geographers conceive the surface of the earth to be divided by certain imaginary lines. These lines, although imaginary so far as the earth is concerned, are real upon maps and globes. They are called *meridians* and *parallels*.

Great Circles are those which pass through the centre of the earth and divide it into equal parts called hemispheres; *small circles* are those which divide the earth into unequal parts.

The circumference of every circle may be divided into three hundred and sixty parts, called degrees; each degree is divided into sixty minutes, and each minute into sixty seconds. Degrees, minutes, and seconds are designated respectively by the characters ° ' and "—thus, 34° 25' 58".

The Equator is a great circle perpendicular to the axis. It divides the earth into the *northern* and *southern* hemispheres.



Parallels of Latitude are small circles parallel to the equator. Two of these are known as *polar circles*, and two others as *tropics*. They are important because they mark the limit of the

in which a pendulum of given length performed its vibrations. If the earth were perfectly spherical, the rate of vibration of such a pendulum would be the same at all parts of the earth's surface. It is found by careful observation that the rate of vibration varies with latitude, being somewhat greatest in latitudes where the flattening is greatest. By means of the pendulum experiments, it is found that a diameter extending from about 28° north to the corresponding degree south latitude is a little longer than it would be if the earth were a true oblate spheroid.

⁴The *statute mile* is 5820 feet long; the *geographical mile* is one-sixtieth of a degree of latitude (one minute of arc), and is 7075 feet long. Unless otherwise designated, statute miles are referred to in this book. The geographical or nautical mile is used chiefly by sailors.

¹From the Greek word *planētes*, a wanderer; a heavenly body that revolves about the sun.

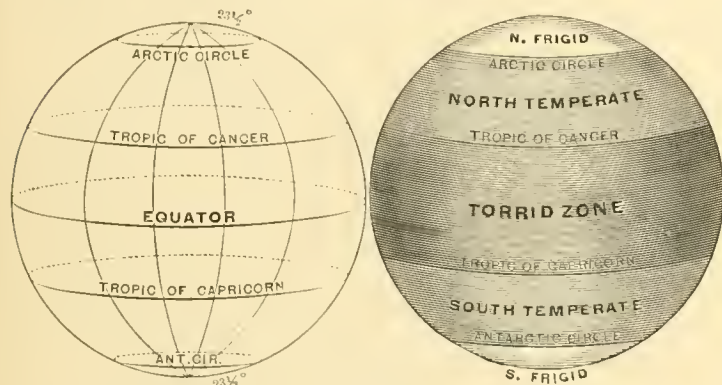
²A similar and very striking illustration may be seen from the railway trains which traverse the Gila Desert in Arizona. Just after the west-bound train leaves Tucson, the top of a certain peak protrudes above the horizon which bounds the perfectly flat expanse of desert. As the train approaches it, more and more of the peak appears, and finally a mountain several thousand feet high comes wholly into view.

³A series of interesting observations, made recently under the direction of the U. S. Coast Survey, show that the earth has a somewhat "square-shouldered" form, and that it is not a true oblate spheroid, as has been commonly supposed. This result has been reached by noting the time

sun's rays at certain seasons of the year. One, the Arctic circle, is $23^{\circ} 27'$ from the north pole; the other, the Antarectic circle, is $23^{\circ} 27'$ from the south pole. The tropic of Cancer is a small circle $23^{\circ} 27'$ north of the equator; the tropic of Capricorn is a small circle $23^{\circ} 27'$ south of it.

Meridians are great circles passing through the poles of the earth. They are perpendicular to the equator.

7. Zones.—Zones are belts encircling the earth. They are included between the tropics, the tropics and the polar circles, and the polar circles and the poles. They are five in number. The space between the tropics is called the *torrid zone*; that



included between the tropic of Cancer and the Arctic circle is the *north temperate zone*. The *south temperate zone* is included between the tropic of Capricorn and the Antarectic circle. The two *frigid zones* lie between the poles and the polar circles.

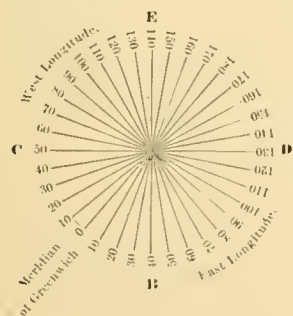
The zones have received their respective names on account of the different degrees of heat they receive from the sun.

8. Latitude and Longitude.—The position of a place on the earth's surface is determined by its *latitude* and *longitude*.

The **latitude** of any place is its distance north or south of the equator, measured in degrees, minutes, and seconds. Latitude is reckoned from the equator to the poles.

Regions north of the equator are in north latitude; those south of the equator are in south latitude. Two or more places situated, for instance, on the 20th degree of south latitude, are said to be on the same parallel, because the same circle passes through them. Degrees of latitude increase in length from the equator to the poles, the length of a degree at the equator being 68.7 miles, but at the poles, 69.4 miles.

The **longitude** of any place is its distance east or west, measured in degrees, minutes, and seconds, from a meridian taken as a standard. On maps, the figures designating degrees of longitude are placed usually at the top and at the bottom.¹



¹ Until recently, in most of the kingdoms and states of Europe the meridian which passed through the principal observatory was taken as a standard. Within a few years, however, most of the civilized nations have agreed upon the meridian of Greenwich as the standard from which to reckon longitude.

² This was taught by Pythagoras, a Greek philosopher, five hundred years before the Christian era, but the theory was rejected by succeeding astronomers, who regarded the earth as the centre of the universe, around which all the heavenly bodies revolved every twenty-four hours. The true theory was revived by Copernicus, in the sixteenth century.

Longitude is reckoned east and west from the standard meridian, being measured in each direction from 0° to 180° . Places lying west of the standard meridian are said to be in *west* longitude, up to 180° ; those to the east, in *east* longitude, to the same extent.

This is shown in the accompanying figure, where the circle CEDB represents the equator, and A the pole of the earth.

Because the meridians converge toward the poles, degrees of longitude vary in length at different latitudes. At the equator the length of a degree is about 69 miles; at the 20th parallel, nearly 64.8 miles; at the 40th, about 52.8 miles; and at the 80th parallel, only 12 miles. At the poles it becomes nothing.

9. Motions of the Earth.—The earth has two motions: *first*, a *daily* rotation about its axis from west to east, causing the succession of day and night; and, *secondly*, a *yearly* revolution around the sun, which gives rise to the change of seasons.²

10. Daily Motion.—The fact that the earth revolves upon its axis rests upon the following proofs:

i. It is impossible, from the laws of centrifugal motion, that the heavenly bodies should revolve daily about the earth; but it is perfectly consistent to consider their motion as *apparent*, and due to a *real* motion of the earth.

ii. The flattening of the earth at its poles is an effect of rotation. Newton proved its figure to be that of an oblate spheroid before the fact was shown by actual measurements.

iii. Balls falling from the summit of a high tower strike the ground *east* of the point whence they started. The top of the tower moves more rapidly eastward than the base, as it is farther from the axis of the earth, and consequently has a greater centrifugal force. In 1804, thirty balls were dropped from Michael's Tower, in Hamburg, from the height of 235 feet. The deviation from a perpendicular was found to be *one-third* of an inch. The annexed cut illustrates this. A ball dropped from B does not take the direction of the perpendicular BB', but that of the inclined line BD.



iv. The diminished weight³ of a body at the equator indicates a centrifugal force resulting from the rotation of the earth. A body removed from the poles to the equator would lose by this force $\frac{1}{289}$ of its weight.

v. All other planetary bodies, so far as known, revolve on their axes; and it is reasonable to infer that the earth also revolves on its axis.

11. Annual Motion.—The revolution of the earth around the sun⁴ is performed in 365 days, 5 hours, 48 minutes, and 46 seconds—a period of time called a *year*. The path or orbit in which the earth whirls around the sun is an oval-shaped figure or ellipse. The orbit of the earth, and, indeed, the orbits of the

³ A body removed from the equator to the poles gains $\frac{1}{289}$ of its entire weight; $\frac{1}{289}$ is due to the flattening of the earth at the poles. The difference between $\frac{1}{289}$ and $\frac{1}{289}$, equal to $\frac{1}{289}$, still remains to be accounted for; and the rotation of the earth does account for it.

⁴ Besides the daily and the yearly motion, the earth, together with the rest of the solar system, is constantly sweeping on through space. Neither the rate of motion, nor the direction in which the solar system is moving, is with certainty known. There is much evidence to show that the direction is towards the constellation Hercules, from the fact that the stars of that constellation are apparently spreading out.

other planets, are so slightly elliptical as to be hardly distinguished from circles. The orbit of the earth differs from a circle by about one-sixtieth of its diameter.

The sun is not situated at the centre of the ellipse, but at a point called the *focus*.¹ The earth is, therefore, nearer the sun at one time than at another. When nearest the sun it is said to be in *perihelion*; when farthest away, in *aphelion*.

The **Ecliptic** is the name of the earth's orbit. The earth is in perihelion about December 21, and in aphelion about June 21. At perihelion the earth is about 90,000,000 miles from the sun; at aphelion, about 93,000,000.

12. Velocity.—The velocity of the earth in its annual motion varies, being greatest at perihelion. The average velocity is about 19 miles a second, or 66,000 miles per hour.

The rotation of the earth on its axis gives to a point situated at the equator a velocity of 25,000 miles a day, or a little more than 1000 miles an hour. But, by reason of the spherical shape of the earth, a point between the equator and either pole will move more slowly, because, moving in a smaller circle, it has not so far to travel.²

This difference in velocity, as will be seen in a following chapter, has much to do with the direction of winds and ocean currents.

13. Length of Day.—During the summer season the length of the day increases with the latitude; in winter it decreases as the latitude increases. The longest days are always in summer; the shortest in winter.

Within the torrid zone, the longest day is about 13½ hours in length; the shortest, 10½ hours. In the temperate zones, the longest day is 24 hours; the shortest, a few minutes in length. In the frigid zones, the days and the nights each vary from a few minutes to six months in length.³

On the 15th and 16th of March, to an observer at the north pole the sun appears to sweep around the horizon. Each succeeding day it rises higher and higher, until, on the 21st of June, it is 23° 27' above the horizon. After that time it gradually sinks. By the 15th of September it again skims the horizon, and by the 21st of December it is 23° 27' below it.

14. The Seasons.—The change of seasons is due to the following causes:

I. The sun illumines but half of the globe at a time.

II. The direction of the earth's axis is always the same, being inclined 23° 27' from a perpendicular to the ecliptic.

On the 20th of March the sun's rays are perpendicular to the earth's axis, illuminating the half of the earth on which they fall from pole to pole. As the earth revolves on its axis, every place on its surface is now twelve hours in darkness and twelve in light. It is then spring in the northern hemisphere and autumn in the southern.

As the earth moves on its course, the circle of illumination gradually overlaps the north pole and recedes from the south pole.

In the northern hemisphere, the days increase and the nights decrease in length; in the southern hemisphere, the reverse occurs.

On the 21st of June the circle of illumination reaches its limit. The rays of the sun then extend 23° 27' beyond the north pole to the Arctic circle, and fall short of the south pole by the same amount, reaching to the Antarctic circle. Within the former circle continual day reigns, and within the latter unbroken night.

In the northern hemisphere it is the beginning of summer, and the time when the days are longest and the nights shortest. In the southern hemisphere it is the period of winter, when the nights are longest and the days shortest.

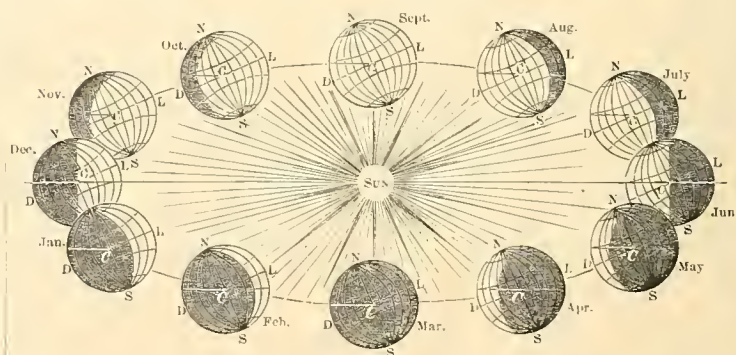
As the earth recedes from the summer solstice,⁴ the circle of illumination returns by degrees to the north and south poles, lengthening the nights in the northern hemisphere and the days in the southern.

On the 22d of September the sun's rays again reach from pole to pole, making the days and nights once more equal in length. This is the autumn of the northern hemisphere and the spring of the southern.

The earth still moving forward in its course, the circle of illumination gradually withdraws from the north pole, and extends beyond the south pole, lengthening the nights in the northern hemisphere and the days in the southern.

On the 21st of December this change attains its full extent: the rays of the sun then extend beyond the south pole to the Antarctic circle. The regions within this circle now enjoy a continual day; but in the northern hemisphere the sun's rays reach only to the Arctic circle, and this zone is veiled in the gloom of constant night.

It is then winter in the northern hemisphere and summer in the southern, the longest day at that time occurring in the southern hemisphere and the shortest in the northern.



These changes are illustrated in the accompanying cut, where the twelve globes represent the position of the earth in its orbit in the successive months of the year, DCL the equator, and NCS the axis—N being the north pole and S the south.

³ The following table shows the length of the longest day in various latitudes:

LATITUDE.	LENGTH OF DAY.	LATITUDE.	LENGTH OF DAY.
0° 0'	12 h.	63° 48'	22 h.
30° 48'	14 h.	66° 23'	24 h.
49° 2'	16 h.	67° 23'	1 mo.
58° 27'	18 h.	69° 51'	2 mos.
63° 23'	20 h.	90° 0'	6 mos.

⁴ From the Latin *sol*, sun, and *stare*, to stand; because the sun appears to be stationary in the heavens, as regards its apparent motion north or south.

¹ An ellipse may be considered as having two centres, one on each side of the true centre. The centres of the ellipse are its *foci*. The *eccentricity* of the ellipse is the distance between its foci. The eccentricity of the earth's orbit is about 3,000,000 miles.

² The velocity of rotation in different latitudes is seen in the following:

LATITUDE.	VELOCITY PER HOUR.	LATITUDE.	VELOCITY PER HOUR.
0°	1040 miles.	70°	354 miles.
30°	896 "	80°	180 "
40°	793 "	85°	90 "
60°	517 "	90°	0 "

PART TWO.

THE STRUCTURE OF THE EARTH.



IGNEOUS ROCK—BASALTIC COLUMNS, GIANTS' CAUSEWAY, IRELAND.

CHAPTER I.

THE CENTRAL MASS OF THE EARTH, AND ITS CRUST.

I. **The Earth** consists of an outer shell, called its *crust*, and an intensely heated central mass, either solid or plastic.¹

That the interior of the earth is intensely heated is inferred from the following facts:

I. In all deep mines the temperature of the rock increases one degree² for every fifty or sixty feet of descent, after the first hundred feet.³ This is reasonably true in all parts of the world; but the rate of increase differs according to the kind of rock through which the mine passes.

II. Water flowing from an Artesian⁴ well increases in temperature with the depth of the well. The water from the well of Grenelle, at Paris, 1798 feet deep, has a constant temperature of nearly 82°; while the mean temperature of the air in that city is only 53°. The temperature of the water, therefore, increases, on an average, 1° for every sixty-two feet of descent.⁵

III. Hot springs, whose sources are very deep below its surface, also prove the existence and increase of internal heat.

IV. Volcanoes exhibit striking proof of the intense heat of the central portions of the earth. According to Lyell, the most re-

fractory rocks would be melted at the distance of about thirty miles below the surface of the earth, if the temperature constantly increased to this depth at the rate stated.⁶

2. **The Earth's Crust.**—Deep mines and borings have been sunk in different parts of the globe, revealing its structure; but none have pierced farther than a few hundred feet below the sea-level. The greatest depth attained is, at present, at the salt-works at Sprenburg, Prussia, where the boring sinks 4190 feet beneath the level of the ocean.⁷

Our knowledge of the earth's structure extends beyond the depth of two thousand feet, for in many places the rocky strata have been tilted and bent so that their edges have been forced to the surface in inclined and curved positions. Geologists have thus been enabled to study the nature of the globe to the depth of many miles. By a careful study of the position of these strata, we learn that the earth's crust consists of various kinds of rocks, arranged in consecutive order.

Under the name *rock* is included everything that enters into the structure of the earth's surface. It includes not only compact masses of stone, but clay, soil, gravel, sand, etc.

Chemistry teaches us that all matter with which we are acquainted is composed of about seventy elementary bodies. Sixteen



TILTED STRATA OF RED SANDSTONE, LAKE SUPERIOR.

of these, united in different combinations and proportions, form nearly all the known matter of the globe.

These important elements are silicon, aluminum, potassium, sodium, magnesium, calcium, iron, manganese, oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, fluorine, and phosphorus.

¹ In its relation to other heavenly bodies, the earth behaves, not as a solid shell surrounding a fluid central mass, but as a solid body.

² The degrees of temperature are those of Fahrenheit's thermometer, unless otherwise designated.

³ It must be kept in mind that these figures represent an *average*. The rate of increase depends largely on the conductivity of the rock. It is also controlled more or less by the chemical decomposition of the rock.

⁴ By boring into the earth deep enough to reach a subterranean body of water, whose sources are higher than the place of the perforation, a spring or well is obtained, called an *Artesian* well, because such wells were first made in the province of Artois, France.

⁵ Observations on this point were made by Walferdin on two Artesian

wells at Creuzot, in France. The borings were a mile apart, one descending 1900 feet, and the other 2678 feet. The results showed that, to the depth of 1800 feet, the temperature rose at the mean rate of 1° for every fifty-five feet of descent, after which the change was more rapid, being 1° for every forty-four feet.

⁶ It is by no means certain that the molten matter ejected from volcanoes comes from the "molten centre" of the earth. Such authorities as Mallet, Judd, and Le Conte incline to the belief that the ejections of volcanoes are derived from local reservoirs of matter heated by chemical action.

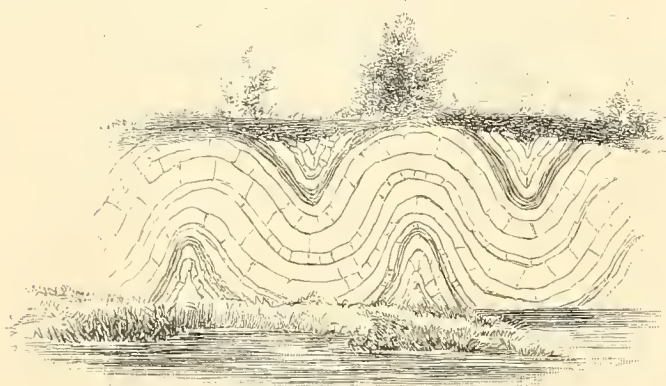
⁷ Great depths have been reached in mines beginning at higher places: thus, the Comstock silver mines in Nevada, among the deepest in the world, descend to the depth of nearly 4000 feet.

Oxygen, combined with one or more of these elements, composes the greater portion of the rocks. It constitutes in itself from a half to a third of the whole crust of the globe. United with hydrogen it forms water, and mixed with nitrogen, the atmosphere. By weight it constitutes *eight-ninths* of all the waters of the earth, and *one-fifth* of the atmosphere.

Carbon forms a considerable portion of all vegetation. Coal consists of it, and it enters largely into the composition of limestone and marble. The diamond is nothing more than pure, crystallized carbon. To silicon we are indebted for glass; and chlorine, in combination with sodium, gives us that most useful article, salt.

ROCKS.

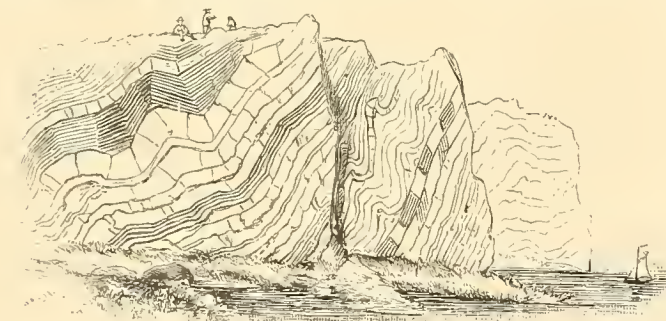
Rocks are divided into three great classes—*stratified*,¹ *unstratified*, and *metamorphic*.²



CURVED STRATA.

3. **Stratified Rocks.**—Stratified rocks occur in layers, usually parallel to one another.

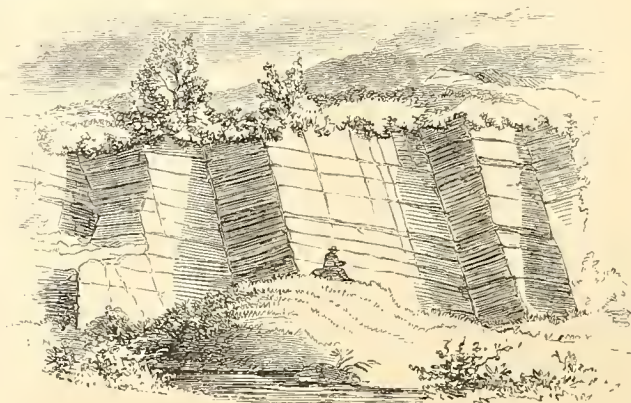
They have been formed by the action of water, which has deposited the sediment in layers, or *strata*. Such rocks have, therefore, received the name of *aqueous* rocks. Sandstone, clay, and limestone are included in this class.



INCLINED STRATA.

Throughout past ages the elements have been incessantly at work wearing away the land. Frost and heat have crumbled

the rocks; rivers and glaciers have ground them to powder; rains and rivers have carried down the sediment and deposited it at the bottom of lakes and seas, where it has become consolidated into beds of rock.

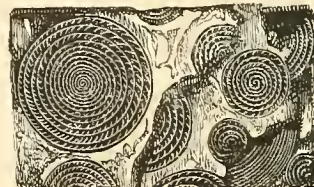


HORIZONTAL STRATA.

But these have not remained at rest; for the contraction of the earth's crust has bent them into vast folds, again to be subjected to the action of the elements, and to pass through the same changes.

Stratified rocks abound in the fossil³ remains of plants and animals, and especially in marine forms. Rocks of this kind are called *fossiliferous*⁴ rocks.

The fossils are sometimes found so perfectly preserved that in the remains of a fish not a scale is wanting; and shells of unknown age have retained not only their shape, but even their colors. These relics have been discovered even



NUMMULITE MARBLE.

on the tops of the loftiest mountains, proving that the highest peaks were once buried beneath the ocean.⁵

The central part of North America is rich in fossiliferous strata, and the valley of the Mississippi abounds in rocks filled with corals, crinoids,⁶ and shells.

Not only are the bones of gigantic animals entombed in the stratified rocks, but fossil organisms so minute exist that *forty-one thousand millions* are contained in a cubic inch of stone.

So widely diffused are the fossiliferous rocks that they are supposed to constitute two-thirds of the surface of the present continents. The study of these rocks is full of interest; for the fossils they enclose reveal to us the former life of our globe.

4. **Unstratified Rocks.**—These, as their name implies, are not formed in successive layers, but occur in masses, which are supposed to have been produced by the action of heat. For this reason they are also called *igneous*⁷ rocks. They are included in three divisions—viz.: *Granitic*, *Trap*,⁸ and *Volcanic*⁹ Rocks.

atic Sea, are composed of fossil shells termed *nummulites*. The nummulitic formation is often thousands of feet in thickness, and is traced from Egypt, through Persia, to the Himalaya Mountains.

⁶ So called from the Greek words *krinos*, a lily, and *eidos*, form; because this family of animals, which are nearly extinct, have the shape of a lily with a jointed stem.

⁷ From the Latin word *ignis*, fire.

⁸ From the Swedish word *trappa*, a stair. It often presents the appearance of a series of steps.

⁹ From *Julean*, who, according to classic mythology, forged the thunderbolts of Jupiter.

¹ From the Latin word *stratum*, a bed.

² From the Greek word *metamorphōsis*, a transformation.

³ From the Latin word *fossilis*, that which is dug out of the earth.

⁴ From the Latin words *fossilis* and *fero*, to bear; i.e., fossil-bearing.

⁵ The amount and extent of these organic remains, microscopic and otherwise, are truly amazing; for each cubic inch of chalk is estimated to contain a million distinct structures. Such organisms form nearly half the bulk of the chalk of Northern Europe, and exceed this ratio in that of Southern Europe. The inorganic portion of the chalk consists of decomposed shells, which cement the fossils into a compact mass. The beds of marble in the Pyrenees, and the limestone range at the head of the Adri-

Granitic Rocks are those which bear the marks of having first been fused far down in the interior of the earth, cooled under the pressure of overlying rocks, and finally upheaved by internal forces. To this class belong *granite*,¹ *syenite*, and *porphyry*.

By many geologists, granite is thought to have been formed from the fragments of certain minerals which have been partly fused together *in the presence of steam*, under enormous pressure, and at a very high temperature.

Trap Rocks are regarded as the lavas of volcanic fissures long since extinct, the molten mass having been forced up through fissures and spread over the surface in vast sheets.

The igneous origin of trap rock is clearly revealed where it breaks through stratified rock, as sandstone; for the junction exhibits undoubted evidence of fusion.

Trap rock has a tendency to form into hexagonal columns of remarkably uniform size.

Basalt, a variety of trap, displays this peculiarity in a remarkable degree. Ranges of regular basaltic columns are found



BASALTIC COLUMNS, REGLA, MEXICO.

in different parts of the world. In places the Columbia River flows between precipices of basalt two thousand feet high.

A fine formation of this kind exists at Regla, in Mexico. The Giants' Causeway, in Ireland, and the wondrous Cave of Staffa, display also the columnar form of basaltic rocks.

Volcanic Rocks are the lavas of volcanoes which have cooled in the air. *Tufa*, *obsidian* (or volcanic glass), and *pumice-stone* (or volcanic froth) belong to this class of rock. Volcanic rocks are usually porous, and in appearance resemble the slag that runs from smelting-furnaces.

5. Metamorphic Rocks.—Metamorphic rocks are those which have been subjected to intense heat and pressure in the

¹ Granite is composed of the minerals *mica*, *feldspar*, and *quartz*. Granite which contains hornblende in the place of mica is called *syenite*. Granite or syenite having a stratified appearance is called *gneiss*.

presence of water. They possess usually a crystalline structure. Clay has thus been transformed into slate, sandstone into quartz, and limestone into marble. These, with gneiss and mica slate, compose the principal rocks of this group.²

Few organic remains are found in rocks of this kind, the intense heat to which they have been subjected having, it is supposed, destroyed nearly every vestige of life-forms.



FOSSIL FOREST RESTORED. COAL PLANTS.

1. Lepidodendron. 2. Sigillaria. 3. Araucaria. 4. Pandanus. 5. Zamia

CHAPTER II.

THE FORMATION OF THE EARTH.

1. Formative Processes.—From all the researches made by geologists it appears that the earth was once in a molten state, and gradually cooled by radiation, until a solid crust had formed. This shell, composed of materials which are bad conductors of heat, prevented further cooling, and thus has preserved the high temperature of the central mass.

Its present state is the result of changes extending through unknown periods of time. Its surface has been remodelled again and again. Mountains have been submerged beneath oceans, and the beds of the latter upheaved into Alpine ranges, until, through successive transformations, it has been gradually perfected and adapted to its present use.

The changes in the condition of the earth have also wrought changes in plants and animals; and their stony imprints, imbedded in the rocks, are the records of these transformations.

Igneous and metamorphic rocks, destitute as they are of fossils, tell little of the lapse of time in the construction of the earth; but the aqueous rocks, filled with relics of life, unfold the successive chapters of its history.

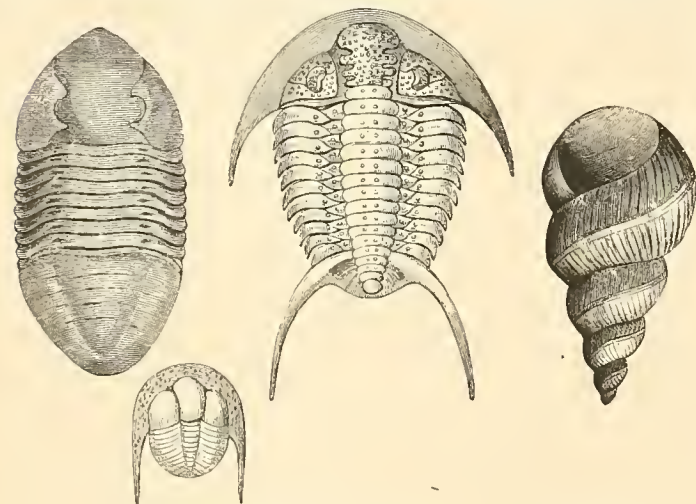
² Metallic veins, which are fissures filled with ore, are most frequently found in metamorphic rocks, but are by no means confined to them, for such veins occur even in recently-formed rocks.

2. **Classification.**—The fossiliferous rocks are classed under several great divisions called *Eras*, corresponding with the order of time in which their strata were formed. They are: the *Palæozoic Era*, during which the first forms of life appear; the *Mesozoic Era*, or age of reptiles; and the *Cenozoic Era*, or age of mammals. These eras possess prevailing types of life so unlike one another that they are considered as great epochs of creation. To these may be added the *Psychozoic Era*, or age of man.

3. **Palæozoic Era.**—This is the period of the oldest fossiliferous strata, in which are found corals,¹ crustacea,² mollusks,³ fishes, and a few reptiles. It is distinguished from other eras by its extraordinary vegetation. From the Arctic to the Antarctic zone, trees and plants of luxuriant growth overspread its surface.

Pines, araucarias,⁴ beautiful tree-ferns, calamites,⁵ and stately palms cast their shadows upon the teeming soil, mingling with lowlier plants of singular form and beauty.

For centuries forest succeeded forest, and the dense vegetation fell, layer upon layer, on the soil where it had grown, gradually

FOSSIL CRUSTACEANS. (Trilobites).⁵

FOSSIL MOLLUSK.

changing into vast beds of coal, which have been treasured up for the use of man.

The succession of fossil forests has been distinctly traced in the carboniferous strata. In the cliffs bordering the Bay of Fundy

¹ From the Latin word *crusta*, a shell; a class of articulate animals having a shell covering, as the crab.

² From the Latin word *mollis*, soft; animals having soft bodies and no internal skeletons, as the snail.

³ A kind of pine, only a few species of which now exist, one of which grows in Araucania, in South America.

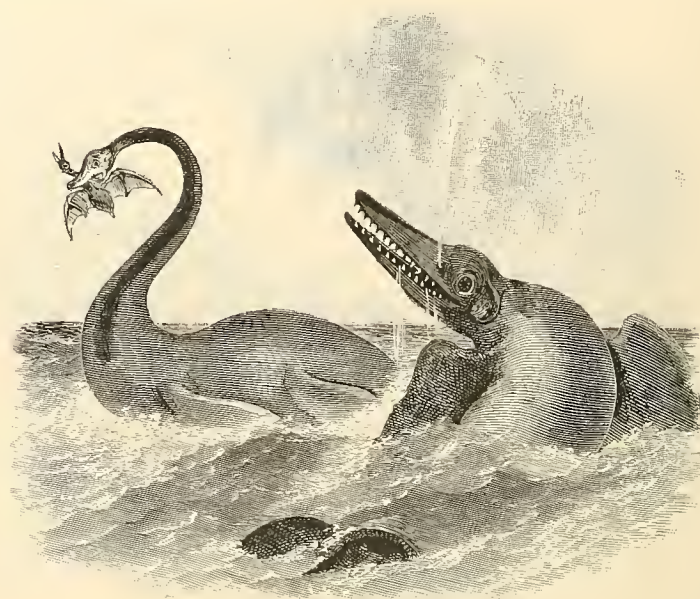
⁴ From the Latin word *calamus*, a reed; a family of plants like the rushes and cat-tails of the present day.

⁵ From the Greek words *tris*, three, and *lobos*, a lobe; a three-lobed animal, and one of the earliest forms of life.

⁶ It is the belief of geologists that at the beginning of this period the atmosphere was so heavily charged with carbonic acid gas that it was unfit for the respiration of the higher classes of animals, while it eminently conduced to the growth of plants, whose food is carbon.

seventeen tiers of erect fossil trees have been discovered at different levels. They extend through a formation more than 4500 feet in thickness. From researches at Cape Breton it appears that *fifty-nine* fossil forests are ranged one above the other throughout the coal formations of this region.⁶

4. **Mesozoic Era.**—The peculiarity of this era is the existence of enormous reptiles of the lizard kind. Such were the



PLESIOSAURUS DEVOURING A PTERODACTYL.

ICHTHYOSAURUS.

*ichthyosaurus*⁷ and the *plesiosaurus*⁸—marine animals that abounded in the seas of this period.

The *ichthyosaurus* was a cold-blooded, air-breathing, carnivorous monster, with the teeth of a crocodile and the head of a lizard. Its jaws were sometimes *six feet* long, and armed with more than two hundred teeth.⁹

The *plesiosaurus*, which belonged to the same type, was remarkable for its long serpent-like neck. It moved through the water by the aid of paddles, or flippers.

Contemporary with the marine animals just described were huge land reptiles of similar species, such as the *iguanodon*¹⁰ and the *megalosaurus*.¹¹ The *iguanodon* exceeded the elephant in size, and, like the latter, it fed upon vegetables.¹²

The *megalosaurus* was a gigantic lizard, carnivorous in nature.

But the most extraordinary creature of this period was the *pterodactyl*,¹³ which somewhat resembled a bat, but was closely allied to the lizard. Its extended wings measured four feet across, from which projected fingers, armed with hooks.

During this epoch colossal birds stalked over the earth. Their

⁷ Fish-lizard. So called from the Greek words *ichthus*, a fish, and *saura*, a lizard.

⁸ Lizard-like. So called from the Greek words *plesios*, near, and *saura*, a lizard.

⁹ Skeletons of this extinct race, varying from five to thirty feet in length, are found in great quantities in England, in the valley of the Avon, and on the coast of Devonshire. The half-digested remains of fishes and reptiles, found within the skeletons, indicate the nature of their food.

¹⁰ So called from its resemblance to the *iguana*, a species of lizard found in South America.

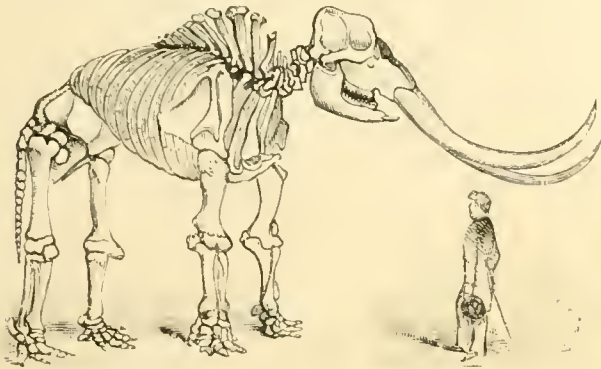
¹¹ So called from the Greek words *megalos*, great, and *saura*, a lizard.

¹² Its proportions were immense. The circumference of the body is estimated at fourteen and a half feet, and the length of the animal at seventy feet.

¹³ So called from the Greek words *pteron*, wing, and *daktulos*, finger.

tracks, from eighteen to twenty inches long, impressed upon the rocks, remain to the present time. Several species of these possessed, instead of beaks, jaws set with socket teeth.

5. **Cenozoic Era.**—This era is marked by the beginning of phenomena very similar to those now in progress on the surface of the earth. The rocks are much like those which continue to be formed at the present day by the deposits of seas, rivers, and

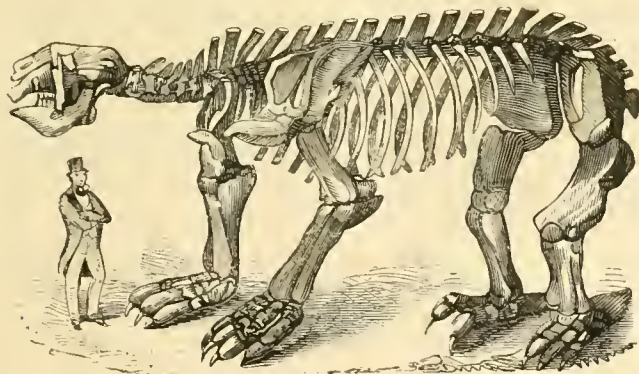


SKELETON OF THE MASTODON.

lakes; and the life-forms resemble those of species now existing rather than those of preceding ages.

The remains of the *mammoth*, or fossil elephant, are found in Europe and North America as far north as the seventy-second parallel of latitude. In Siberia they have been discovered in such quantities that the deposits are known as *ivory quarries*.

Not only have the bones and tusks of these huge animals been brought to light, but in one case the entire body was discovered,



SKELETON OF THE MEGATHERIUM.

encased in frozen mud, its flesh and skin as fresh as though it had been recently entombed.¹

The *megatherium*² was another giant quadruped. Its head and neck were like those of the sloth, and its feet were armed with claws of enormous length. It was an unwieldy animal, but

¹ In the year 1799 a fisherman observed in a cliff of ice and gravel, along the banks of the Lena River, a shapeless mass, which, as soon as the ice thawed away, proved to be the complete body of a mammoth. It was twelve feet high and about sixteen feet long, while its curved tusks were nine feet in length. The body was in such a state of preservation that dogs and wolves preyed upon the flesh. The skin was covered with coarse hair, fifteen inches long. Allied to the mammoth was the mastodon, probably the largest land-animal known. The bones of the mastodon are found in many parts of the world. Numerous skeletons have been uncovered in Kentucky, New York, and the river gravels of California. A very perfect

specimen was discovered in a marsh near Newburg, New York. This animal was found in a nearly erect position. Its teeth were filled with the half-chewed remnants of spruce and fir twigs. It had probably become mired in the bog while in search of food.



MEGATHERIUM.

MAMMOTH.

6. **Psychozoic Era.**—At the beginning of this era the land, which during preceding ages had been repeatedly reconstructed, assumed its present configuration. Most of the older forms of life had perished. The earth was to be clothed again with new plants and to be filled with new races of animals.

The mighty changes which had occurred during the past were preparations to fit the crude planet for a dwelling-place for the human race. Beneath its surface immense treasures had been accumulated, sufficient for all the demands of man in his onward march of civilization.

There lay coal-fields almost limitless in extent. There were also vast deposits of useful metals, without which the physical progress of the world would have been impossible.

On the surface of the earth, rocks which had been worn away by the waters, crumbled by frost and heat, were spread over the valleys and plains.

As time advanced, the decay of forests enriched the soil; and over land and sea rested a pure and salubrious atmosphere, ministering to the wants of every form of life.

Man, the crowning glory in the history of creation, came at last. Just at what time he first appeared on the earth cannot with certainty be told. The only scraps of his geological history are furnished by the bone-caverns in which his skeleton has been found, and the history furnished by these is too meagre to yield any clue to his intellectual condition.

They show, however, that primeval man lived in caves, and that he existed by hunting. He employed weapons and had

specimen was discovered in a marsh near Newburg, New York. This animal was found in a nearly erect position. Its teeth were filled with the half-chewed remnants of spruce and fir twigs. It had probably become mired in the bog while in search of food.

² So called from the Greek words *me-gas*, great, and *thérion*, a wild beast. This gigantic animal attained a length of eighteen feet, and measured around its body fourteen and a half feet. A skeleton of the megatherium was found in a bed of clay one hundred feet below the surface near Buenos Ayres. This animal was confined chiefly to the pampas of South America.

learned the use of fire. This, in itself, was one of the most potent agents to insure his social and intellectual development.¹

7. Changes in Progress.—Within the recent period important geological changes have occurred, which are still in progress. The sea in some places has encroached upon the land, and in others the land upon the sea: so that the waves now sweep over the sites of ancient cities, and bays and arms of the sea have been transformed into solid land.²

Heat, as well as water, has likewise been at work during this era; for not only do the annals of the past tell of the elevation and subsidence of parts of the earth's surface, but at the present time the same phenomena are constantly taking place in nearly every part of the world.

The slow elevation or depression of different countries is a still more wonderful display of the changes that are yet at work upon the earth's surface.

The coast of Sweden and Finland is gradually rising, as is proved by the marks established by the Swedish government.³

In Greenland, a part of the coast, for a length of six hundred miles, has been slowly sinking during the last four centuries. Islands have been submerged, and old buildings that formerly stood upon the shore are now beneath the waves.

These changes are supposed to be due to the cooling and contraction of the earth's interior—the crust rising in some places and sinking in others, in order to adapt itself to the decreasing bulk of the earth's interior.



NATURAL TUNNELLED TOWER, MT. SOLON, VA.



GROTTO DES DEMOISELLES.—HERAULT.



NATURAL BRIDGE, VIRGINIA.

PART THREE.

LAND.

1. Extent.—The surface of the globe is estimated to contain 197,000,000 square miles, and is comprised under the two grand divisions of *land* and *water*.

The land occupies only about a fourth of the surface; for its extent is computed at about 52,000,000 square miles. It is also

very unequally distributed; for, while the southern hemisphere contains but 15,000,000 square miles of land, the northern has 37,000,000 square miles, or nearly three times as much.

A similar inequality will be found to exist if we divide the globe into eastern and western hemispheres by a meridian 20° west of Greenwich.

Nearly all of the land is clustered about the north pole, from which it extends in three directions. The mean southern limit of the land masses is the 45th parallel of latitude.

¹ Only a few years since, a nearly perfect skeleton of a prehistoric man was found in a cavern at Mentone, France. The antiquity of this man is undoubted, for his bones were found associated with those of extinct species of animals. Scattered about the cavern were the weapons he used in hunting and a few rude ornaments. There was no evidence of domesticated animals or of agricultural implements. In another cave were found charred embers and half-burned bones.

² In 1399, Henry of Lancaster landed with his adherents at Ravenspur, on the coast of Yorkshire, an ancient seaport, which once rivalled Hull in commercial advantages; yet nothing of it now remains but banks of sand, which are covered by the flood-tide. The Goodwin Sands, so dangerous to

mariners, constituted, in the eleventh century, an extensive lordship, belonging to the powerful Earl Godwin. On the other hand, the place where Julius Caesar landed when he invaded Britain is now far inland. Ostia, in the time of the Romans a port of the Tiber, is now three miles from the water; and Adria, a former seaport near the mouth of the Po, is now twenty miles inland. The great rivers of the globe, such as the Mississippi, the Amazon, the Ganges, and the Nile, are also constantly carrying down to the coast immense quantities of earth, thus causing the land to encroach upon the sea.

³ According to Lyell, the rise at Uddevalla is about four feet in a century, and greater farther north.

CHAPTER I.

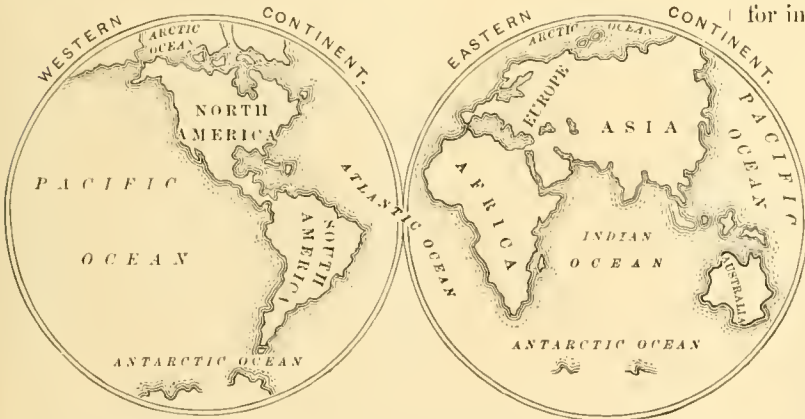
CONTINENTS.

2. **The Land**, in regard to its configuration, is presented under two aspects—namely, its *horizontal outline* and its *relief or vertical elevation*. The first relates to continents and islands; the second, to mountains, table-lands, and plains.

3. **Continents**.—Continents are the largest natural divisions of land. Three such masses of land are now commonly recognized: the *Eastern*, the *Western*, and the *Australian*. The first comprises Europe, Asia, and Africa; the second, North America and South America; the third, Australia and Tasmania. Greenland, which is nearly as large as Australia, is commonly regarded as an island. The continents and the adjacent islands comprise several grand divisions of land, the areas of which are as follows:

Asia.....	17,200,000	South America.....	6,800,000
Africa.....	11,500,000	Europe.....	3,900,000
North America.....	9,300,000	Australia.....	3,400,000

Since the year 1819 various portions of land have been discovered near the Antarctic circle by American, English, French, and Russian explorers, which have been regarded as the northern points of an Antarctic continent; but the question of their connection is not yet settled.¹



4. **Eastern Continent**.—The Eastern Continent extends from Cape Verde, the most westerly point of Africa, to East Cape, the eastern extremity of Asia. It reaches from Cape Chelyuskin, in Siberia, to Cape Agulhas, the most southerly point of Africa.

The area of the Eastern Continent, with its islands, is about 32,600,000 square miles. Its greatest depression is at the Dead Sea, whose surface is thirteen hundred feet below the level of the sea. In Central Asia the land rises, in Mt. Everest, to the height of 29,000 feet.

The great divisions of the Eastern Continent differ materially in size. Europe, the smallest, contains about 3,900,000 square miles. Africa is nearly three times as large, having an area of 11,500,000 square miles; while Asia, whose area is 17,200,000 square miles, is nearly five times as great.

¹ The largest known mass of land in this region was discovered in 1840 by the United States Exploring Expedition, under Captain Wilkes. It extends east and west a distance of 1700 miles. Victoria Land, the next

Europe and Asia resemble each other in several important physical features: both are filled with rich and fertile regions and traversed by vast mountain-ranges and great river-systems, while deep gulfs and bays pierce their coasts.



VILLAGE IN THE HIMALAYAS.

In Africa, the northern part consists of deserts. An elevated plain occupies the interior, which is watered by the streams that flow from the high mountain region. Its coast-line is almost unbroken, but several of the larger rivers present excellent facilities for internal communication.

5. **Western Continent**.—The Western Continent extends from Cape St. Roque, South America, to Cape Prince of Wales, in Alaska. In latitude it stretches from Grinnell Land, 82° north latitude, to the Strait of Magellan.

Its area is computed at 16,100,000 square miles. It is, therefore, only about half the size of the Eastern Continent.



STRAIT OF MAGELLAN.

* The highest point of land on this continent is the peak of Aconcagua, in Chili, which rises to the height of twenty-three

in size, was discovered by Captain Ross, in 1841. The coast of this land is bordered by a range of high mountains. Mt. Erebus, one of the loftiest peaks, is an active volcano.

thousand nine hundred feet above the sea. Depressions below the general surface occur, as in Death Valley and the sink of the San Felipe River, in California, each of which is nearly three hundred feet below the sea-level.

Of the two divisions of this continent, North America is the larger, embracing about 9,300,000 square miles; the area of South America is computed at 6,800,000 square miles.

6. Coast-lines.—The greater the extent of coast-line which any country possesses, in comparison with its area, the more deeply must it be penetrated by arms of the sea. These physical features are of great importance to a country. They not only affect its climate and productions, but they also increase its facilities for commerce by furnishing numerous harbors.

The grand divisions of the globe differ greatly in this respect. The following table exhibits the approximate ratio of the number of square miles in area to one mile of coast, in each division :

Europe.....187	Australia.....340
North America.....266	Asia.....528
South America.....440	Africa.....738

7. Form and Elevation of the Continents.—A glance at a map of the world shows that the great continental masses have a triangular form, the apex pointing towards the south. Thus, South America ends in the promontory of Cape Horn, and Africa in the Cape of Good Hope.

North America grows narrower toward the south, till a mere strip of land separates it at Panama from the Atlantic and Pacific Oceans. Greenland terminates to the south in Cape Farewell, and India in Cape Comorin. Malacca, Arabia, Greece, Italy, and Spain exhibit the same peculiarity.

The mean elevation of the continents depends not so much upon their mountain-ranges as upon the extent of their



GIBRALTAR.

high plains and table-lands. The levelled mountains of Europe would raise its surface but six hundred and seventy feet above the sea-level; those of North America, seven hundred and fifty feet; South America would thus be elevated eleven hundred and

thirty feet; and Asia, eleven hundred and fifty feet. The average elevation of the two continents, omitting Africa, would be only nine hundred and twenty-five feet.¹

A deeply indented coast-line contributes greatly to the prosperity of a nation. The arms of the sea, extending into the land, modify its extremes of climate, and at the same time furnish safe and commodious harbors. In this way not only is commercial intercourse made easy, but civilization and enlightenment are widely extended.

8. Resemblances.—The two continents correspond in certain particulars, but are strikingly dissimilar in others. The Eastern is divided almost across from east to west, the narrow isthmus of Suez alone connecting Africa with Asia.²

On the Western, the waters have made a like encroachment, the Atlantic Ocean forming an immense bay, which almost separates North America from South America.

Both likewise extend, in broad masses of land, to about the same latitude north, and both terminate, towards the south, in vast triangular bodies—South America in the Western Continent, and Africa in the Eastern.

Each has also its great cluster of islands—the West Indian isles being the counterpart of the Eastern Archipelago; and the fiords or rock-bound inlets of Norway do not differ from those that pierce the cliffs of the Patagonian coast.

9. Contrasts.—On the other hand, marked differences exist between the continents. In the Western the general direction of the land is nearly at right angles to that of the Eastern. In the former, the line of greatest length stretches from southeast to northwest; in the latter, it extends from southwest to northeast. The chief mountain-ranges follow similar lines of direction.

If we contrast the northern divisions of the two hemispheres with the southern, striking diversities are likewise perceived. The former far exceed the latter in size, and, owing to their similar climate, and facility of intercommunication, possess a physical unity which South America and Africa do not enjoy.

It is also worthy of remark that the extent of the temperate regions, which are so peculiarly adapted to the full development of man, is far greater in the northern than in the southern zone.

These facts are not to be overlooked when we seek for the reasons why the dominant races of the earth have ever been found within the three northern grand divisions.

10. General Laws of Relief.—I. Nearly every continent has high borders and a low interior.

II. The highest mountain-system faces the largest ocean.

III. Coast-lines are usually parallel to the trends of the principal mountain-systems.

IV. Nearly all of the active volcanoes of a continent are on its borders—comparatively few being in the interior.

V. The continents had their outlines defined in the earliest times, and subsequent changes of level have not materially altered them.

VI. The general directions of coast-lines, mountain-systems, and island-groups are—1st, from northwest to southeast; 2d, from northeast to southwest.

VII. Near the equator a zone of water separates the northern from the southern continents.³

¹ The mean elevation of Africa would probably be sixteen hundred feet, and that of Australia less than five hundred feet.

² The canal across the Isthmus of Suez is not necessarily an arm of the sea. Africa is *naturally* a peninsula, not an island.

³ This belt of water is interrupted only by the Isthmuses of Panama and Suez, the former thirty-seven, the latter one hundred miles in width. The peninsula of Malacca is a similar interruption, but in this case the depression between the peninsula and the adjacent island is below the sea-level.



VOLCANIC ISLAND OF SANTORINI.

CHAPTER II.

ISLANDS.

1. **Islands** constitute one-seventeenth of the land-surface of the earth, or 3,000,000 square miles. They are classified as *Continental* and *Oceanic*. In many instances they are of volcanic origin.

2. **Continental Islands.**—These islands are long in proportion to their breadth. They skirt the shores of continents, extending parallel to the maritime mountain-ranges. They are similar to the adjacent continents, not only in structure, but also in the forms of life which they support.

They are portions of partly submerged mountain-ranges. Such is the chain of islands forming the West Indian Archipelago, and the vast chain on the eastern coast of Asia, which extends from Kamtschatka to Formosa, together with many others which a glance at the map reveals.

England, it is supposed, was once connected with the mainland of Europe, but was separated by an irruption of the sea, which formed the Straits of Dover.

3. **Oceanic Islands.**—These, as their name implies, lie in mid-ocean, and form groups, which are regarded as the summits of submarine mountain-ranges. They are most numerous in the Pacific Ocean, which contains nearly seven hundred groups. A few are scattered throughout the Atlantic and Indian Oceans.

¹ Barren Island, in the Bay of Bengal, belonging to the Andaman group, is one of the most remarkable volcanic islands now active. From the centre of the island rises a cone, eighteen hundred and forty-eight feet high, from which issue vast volumes of smoke and showers of red-hot stones, some of which weigh two or three tons. Only on the outer edges of the island does vegetation exist, but scant and dwarfed, and frequently blasted by the hot and fiery eruptions from the central cone, which is surrounded by a volcanic wall of nearly its own height. The island is about twenty miles in circumference, and at a quarter of a mile from the shore no bottom is found at the depth of one hundred and fifty fathoms.

² The formation of the island was preceded by severe earthquake-shocks,

4. **Volcanic Islands.**—Many islands are evidently the product of volcanoes. Some are still active, and eruptions not infrequently happen;¹ in others the geological features prove unmistakably their volcanic origin. The volcanic islands form several great belts, each thousands of miles long.

The *first* begins with the Banda group of islands, and extends through the Sunda Isles into the Bay of Bengal—a distance of more than twenty-five hundred miles.

The *second* commences north of New Guinea, and embraces New Britain, New Ireland, Solomon Archipelago, the New Hebrides, and New Caledonia.

The *third*, and most important, begins at the Molucca group, and, passing northward, through the Philippine Isles, Formosa, and the Liu Kiu group, extends through the Japan Archipelago, the Kooril Islands, and the peninsula of Kamchatka.

In the Atlantic Ocean, the Azores, and the Madeira, Canary, and Cape Verde Islands, are all of volcanic origin.

In many islands of this chain active volcanoes exist; in others, all commotion appears to have ceased. In Fayal, one of the Azores, the undulations of the lava before it hardened into rock are still seen upon the cliffs that face the ocean.

The **internal forces** which raised these islands from the deep are still at work. In the group of the Azores, new islands appeared successively in the years 1628, 1720, and 1811. The most remarkable of these occurrences is that which took place in the last-mentioned year, near St. Michael.²

and, before they ceased, a dense column of smoke was seen, on the 13th of June, rising from the sea, accompanied with loud explosions and flashes of lightning; and within the column were beheld large quantities of ashes, sand, and cinders. Soon after, a dark mass appeared, which was discovered to be the upper edge of a rock. It gradually increased until it had formed an island a mile in circumference and three hundred feet in height. In a few months the island began to diminish, and in less than a year its site was occupied by a reef, which was covered at high tide. At present the depth of the sea at this spot is sixty fathoms, being twice as deep as it was before the island arose. On the Iceland coast, a new island emerged from the sea in 1783, but in a short time it sunk, and was again covered by the waves.

In 1831, an island, which received the name of Graham Island, rose from the sea near Sicily. It attained an elevation of two hundred feet, and was more than a mile in circumference. By the close of the year it had disappeared, and fifteen years afterwards the sea was two hundred feet deep at this spot.



MADEIRA.
(Volcanic island; extinct.)

The volcanic islands above described have been but temporary formations; but this is not always the case. Thus, the Aleutian group presents instances of recently-formed islands which appear to be permanent. Such are the two added to this group in 1806 and 1814.¹

The most remarkable instances of the kind have occurred in the Bay of Santorini, in the Grecian Archipelago. The island of Santorini is in the shape of a horseshoe, and encloses an oval bay. Within the bay are four islands that have arisen within the period of history—the last as late as the year 1866.

The largest island, Nea Kameni, appeared at a spot where the water had previously been from five hundred to six hundred feet deep. It attained an elevation of thirty feet; and at length a conical mountain arose, three hundred feet high, crowned with a crater. The formation of the island was accompanied with earthquakes and dense clouds of vapor.

5. Coral Formations.—Coral formations occupy a belt of the ocean limited north and south by the isothermal lines of 68°. They are the work of small marine animals belonging to the class of polyps which exist in tropical seas. Coral polyps live together in communities of vast extent, and in appearance are not unlike trees.

The coral skeleton is composed of stony cells, formed of carbonate of lime secreted from the waters of the ocean. The coral rock consists of the united skeletons of dead polyps.

Waves break off fragments from the upper part of the reefs and pile them above the water's surface. Winds and migrating birds

bring seeds from other shores, and in time the island is covered with vegetation, profuse in growth, but limited in variety to a few species of palms.

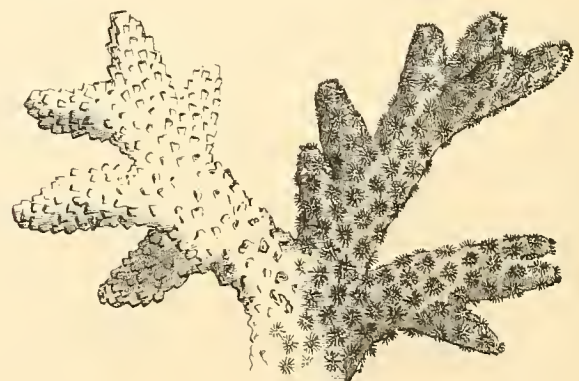
The coral polyp always builds perpendicularly upwards. It cannot exist above the surface of the water, nor at a greater depth than one hundred and twenty feet. Yet the coral rock extends far below this limit; for the depth of water at the distance of a few hundred feet outside the reef sometimes exceeds a thousand fathoms.

This fact is explained by Darwin upon the theory that the bed of the ocean upon which the polyps began to build gradually sunk, and, as fast as it subsided, the polyps built upward to the surface of the water.

There are three different kinds of coral formations: *Atolls*, *Encircling Reefs*, and *Barrier Reefs*. They occur chiefly in the Pacific and Indian Oceans, but they are found also in the West Indies, and in warm ocean waters of various other localities.

6. Atolls.—An atoll consists of a ring of coral enclosing a shallow lake called a lagoon. The width of this ring is, on an average, about a quarter of a mile, and its height above the sea seldom greater than twelve feet, and, unless clothed with foliage, the islands are often imperceptible at a short distance.

On the *outer* side the coral ring slopes gradually into the sea for a distance of about six hundred feet from the shore. Beyond this point the sides sink suddenly to an unfathomable depth. On the *inner* side the ring consists of successive ledges of living



(Dead.)

CORAL.

(Alive.)

coral, the polyps being of a different species from those which construct the outer portion of the ring. The depth of the lagoon varies from one hundred and twenty to three hundred feet.

Atolls are sometimes circular, but generally oval, or irregular in form. There are openings in the ring, through which the tide enters, and in which ships find secure harbors.²

Islands of this class occur both singly and in groups; but they are usually found in extended archipelagoes. The most remarkable instances of this kind in the Pacific Ocean are the Paumotu group and the Caroline Archipelago.³

¹ The first of these, now called Bogosloff, was ten years in forming. It appeared in 1796, and gradually increased until 1806. In the latter year it was visited by explorers, the soil, before that time, being too hot to tread upon. It took several hours to sail around the island. The second island reached an altitude of nearly three thousand feet; but both have since remained. In 1882 Bogosloff was the scene of an eruption.

² Coral islands vary in length from two to about ninety miles. The atoll of Suadiva is forty-four miles long and thirty-four broad; while one

belonging to the Maldive group has a length of eighty-eight miles, and is from ten to twenty miles across.

³ The Paumotu group, which lies east of the Society Islands, is composed of eighty atolls. The coral rings rise ten feet above the sea, which beats upon them with tremendous force. The Caroline Archipelago surpasses all others in number. It contains no fewer than *sixty groups* of atolls, stretching through a distance of more than two thousand miles. Many of these are of great extent, and all are exposed to the sweep of violent seas.

7. Encircling Reefs.—These differ from atolls only in the fact that within the lagoon one or more islands occur, which are usually of great height, and at a distance of two or three miles from the shore. The encircling reef rises on the outside from a very deep ocean. Within it is separated from the island by a



LAGOON ISLAND, OR ATOLL (SOUTH PACIFIC).

shallow channel. The reef, it is supposed, surrounds the submarine base of the island.¹

Tahiti, the chief of the Society Islands, affords a fine example of the encircling reef. It is enclosed by a narrow coral reef, from which it is separated by a shallow lagoon from half a mile to three miles broad. The island towers to the height of seven thousand feet. Its lofty sides are clothed with forests of cocoanut, bread-fruit, and palms, and the varied productions peculiar to coral islands.

8. Barrier Reefs.—Barrier reefs are vast coral walls, running parallel to the coasts of a continent or an island—in the latter case skirting only a portion of the shore. New Caledonia has a reef of this kind, which extends for a distance of four hundred miles along the shores of the island.

But the finest instance is the Great Barrier Reef on the north-east of Australia. This wonderful rampart, ranging in breadth from six hundred to five thousand feet, skirts the coast for more than one thousand miles. Throughout its whole line it is nearly unbroken; a few openings only admit vessels into its vast sound.

9. Theory of Formation.—There are reasons for believing that a large part of the Pacific in the tropical regions was once occupied by a continent, the greater part of which has sunk below the level of the sea.

By this subsidence the tops of the mountains and table-lands were changed into the islands and archipelagoes that now exist.² This theory, according to Darwin, explains all the varied appearances presented by the coral formations.

An inspection of the map will reveal the fact that most of the islands of Oceanica are ranged in parallel lines having a north-

¹ The island of Hogolen, one of the Caroline Archipelago, exhibits a fine example of the encircling reef. Here the coral rampart is one hundred and thirty-five miles in circuit, having channels so wide and deep that ships of the largest size can enter the lagoon with ease and moor in safety. Within the lagoon are six or eight islands, which rise to a considerable height.

northwest trend—a physical feature which only a partly sunken mountain-chain would present.

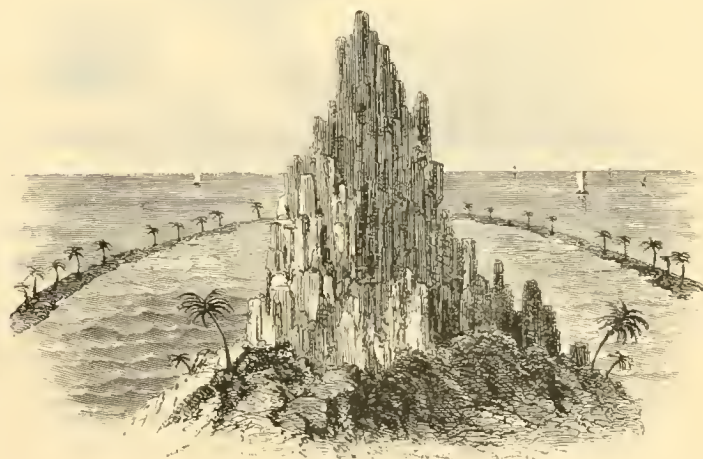
10. Size and Arrangement of Islands.—Islands vary in size, from the smallest spots upon which the sea-fowl rests, to immense masses of land that vie with continents in their dimensions. Instances of the latter are Madagascar, Borneo, the British Islands, and the Japan Islands.

Because they are swept by mild ocean winds, these islands are characterized by a moist and temperate climate and a fertile soil—qualities that render them capable of supporting, as they do, a far denser population than the most favored continent.

Islands, as we have seen, exist commonly in groups and archipelagoes, and seldom occur alone. Single islands are usually small, and, in most instances, of volcanic origin. The most remarkable examples of this class are Ascension Island and St. Helena. The former is fourteen hundred and fifty miles from the African coast. St. Helena is eighteen hundred miles from the coast of Brazil and twelve hundred from Africa. It rises abruptly from the ocean, a huge mass of volcanic rock, several thousand feet in height.

11. Wave-Formed Islands.—A remarkable feature on the Atlantic coast of the United States is noticeable in the long and narrow islands which skirt the shore from Sandy Hook to the Rio Grande River.

Most of the rivers of the Atlantic slope are charged with sediment, and the greater part of this is deposited just beyond their mouths. But while the current of the river tends to carry it seaward, the waves push it landward. It therefore accumulates in the form of narrow bars or spits, of which Hatteras Reef and Padre Island are examples.



ENCIRCLING REEF. (BALABALA, IN THE PACIFIC.)

The shape and position of such islands are frequently changed by the beating of the waves upon them; and in more than one instance a succession of severe storms has entirely washed away large islands, and rebuilt them at a considerable distance from their original locations.

² The lines of islands over the ocean are as regular and as long as the mountain-ranges. To judge of their apparent irregularities, we must remember that, in systems like the Rocky Mountains or the Alps, the ridges vary more or less in direction, and that the peaks of a ridge are far from being in an exact line, even over a short course.—DANA.

CHAPTER III.

MOUNTAINS, VALLEYS, AND PASSES.

1. **Mountains** are the higher elevations of the land. They vary in altitude from twenty-nine thousand to two thousand feet above the sea. All inferior elevations are termed *hills*.

Single mountains, unconnected with similar heights, are of



THE SUMMIT OF THE ALPS.

rare occurrence, and in nearly every instance are volcanic. Such are Mount Egmont in

New Zealand, Stromboli in the Mediterranean, and the Peak of Teneriffe on one of the Canary Islands.

2. **Structure.**—Mountain-ranges consist of immense wrinkles or folds in the stratified rocks which form the outer part of the earth's crust. Sometimes there is but a single fold, but oftener a series of folds parallel to one another. A single fold is called a *range*; a series of ranges constitute a *system*.

The central range of a system is usually higher than the others, and constitutes the crest or "divide" of the system. The extremities of a chain are nearly always its lowest elevations, while the loftiest points are near the central part.

From the main system secondary chains not infrequently branch off at different angles, as in the case of the Sierra Nevada Mountains and the Alps. Mountain-systems extend usually in



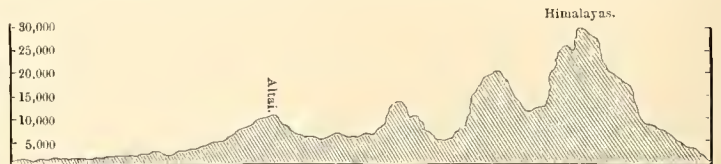
PROFILE OF SOUTH AMERICA FROM THE ATLANTIC TO THE PACIFIC.

the direction of the greatest length of the continents in which they occur; but their course is by no means unvarying; for they frequently deviate from their prevailing direction in angles and irregular spurs. The vast chains formed by the Rocky and Andes Mountains afford striking illustrations of this law.

¹ According to Malte Brun, this peculiarity is subject to no constant rule, but is dependent upon local causes; yet it appears to be the case that the slope is commonly towards the mainland, while the steep declivity faces the sea. This feature is particularly marked in the contiguous ranges of the Pyrenees and Cantabrian Mountains, where, as just stated,

3. **Slopes.**—In all the continents the surface rises gradually from the sea-shore to the high mountain-systems of the interior; but these do not occupy a central position; and, on this account, a gentle broken slope usually exists on one side of the chain, and an abrupt descent on the other.

Thus, the Andes descend abruptly towards the Pacific, but gradually towards the Atlantic. The Atlas and the Taurus

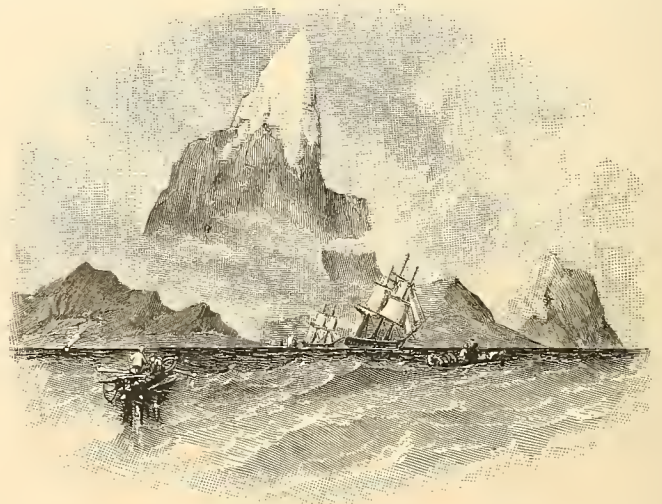


PROFILE OF ASIA FROM THE ARCTIC OCEAN TO THE BAY OF BENGAL.

Mountains present their most rugged sides to the Mediterranean. The Pyrenees are also steeper towards the south than towards the north. In the United States the Appalachian system exhibits the same structure, sloping abruptly towards the east and gently towards the west.¹

4. **Relation between Mountain-Systems and Oceans.**—According to Professor Dana, the highest mountain-system in each grand division of the globe faces the largest ocean. Thus, in the Western Hemisphere the lofty chains composing the Rocky and Andes Mountains look towards the Pacific, while the lower ranges of the Alleghany and Brazilian Mountains face the Atlantic.

In the Eastern Hemisphere the same law obtains. The Himalayas, the highest mountains in the world, confront the largest expanse of ocean on the globe. In Africa, the loftiest peaks are on the side of the Indian Ocean, and in Australia they are directed towards the Pacific, the larger of its bordering oceans.



PEAK OF TENERIFFE, CANARIES.

Mountain-chains are intersected by valleys and broad table-lands, which, in the higher elevations, are bleak and sterile. At lower altitudes, valleys of wonderful fertility are spread out between their ranges.

the positions of the precipitous sides are reversed. A glance at the map shows that the Bay of Biscay is north of the Cantabrian Mountains, and the mainland of Spain towards the south; while France lies north of the Pyrenees, and the Mediterranean breaks upon this range at its southern extremity.

The two great divisions of the land—the Eastern and the Western Hemisphere—exhibit a remarkable contrast in respect to their reliefs: in the former the mountains and table-lands predominate, and in the latter the plains.

NORTH AMERICAN MOUNTAIN-SYSTEMS.

5. Rocky Mountain System.—These lofty mountains,¹ which comprise many parallel ranges, extend from the Arctic Ocean, in a southeasterly direction, to the Isthmus of Panama.

In the United States the Eastern and the Western ranges spread out and form the Great Basin.

In Mexico they constitute the high table-land which culminates in the towering volcanic cones of Popocatepetl and Iztaccihuatl. The entire length of this immense system is about five thousand eight hundred miles.

The Western Ranges of this system extend along the Pacific coast, from which they are never distant more than about one hundred and seventy-five miles. They begin in about the same latitude as the Rocky Mountains, and extend southward under the names of the Beaver Mountains, Cascade Range, and Sierra² Nevada Mountains. Parallel to these ranges, but lying close to the coast, is the Coast Range. Mount St. Elias, the highest peak of the Rocky Mountain system, attains an altitude of 19,500 feet.

The Rocky Mountain system, with the plateaus existing between their various ranges, constitute one of the largest mountain-systems of the globe. The bulk of the uplifted land surpasses that of the South American Andes, being twice as broad as the latter, and exceeding it in length by a thousand miles.



PIKE'S PEAK, ROCKY RANGE.

6. Appalachian System.—This system comprises the mountain-ranges bordering the Atlantic Ocean, extending south-westerly from Labrador to Alabama and Georgia.

It begins with the Watchful Mountains, north of the Gulf of

¹ In Colorado alone there are about one hundred and thirty peaks, each having an altitude of 13,000 feet or more.

St. Lawrence. South of this belt are the ranges of the Notre Dame, White, Adirondack, Green, and Catskill Mountains, and these are succeeded by the Alleghany Mountains, which are prolonged to the southern extremity of this mountain-zone.



VOLCANOES OF POPOCATEPETL AND IZTACCIHUATL, MEXICO.

The entire length of this chain is about two thousand miles. It is composed of numerous parallel ridges, whose summits rise seldom higher than about four thousand feet above the sea. Its loftiest elevation, Mt. Mitchell, is 6711 feet in height.

Ranges of mountains traverse the three principal West Indian islands—namely, Cuba, Hayti, and Jamaica. Two mountain-chains extend through Hayti, the highest of which is the Cibao Mountains. In Jamaica the Blue Mountains extend through the whole length of the island.

SOUTH AMERICAN MOUNTAIN-SYSTEMS.

7. Andean System.—This chain extends from the Isthmus of Panama along the whole length of the Pacific coast of South America, terminating in the rugged promontory of Cape Horn. Its component systems are the Andes of Colombia, and the Andes of Ecuador, Peru, Bolivia, and Chili.

In Colombia the chain consists of *three* parallel ranges, but in Ecuador it is composed of but two. In Peru, the Andes extend northward from the knot of Pasco in three immense belts; to the south, in two ranges. The Andes of Chili, consisting of a single ridge, are prolonged through Chili to Cape Horn.

For nearly seven hundred miles along the coast the Andes of Chili rise from the sea-level—colossal walls of rock, cleft by wave-worn fiords or scored by huge glaciers.

The Andean system has a length of four thousand eight hundred miles, and a breadth varying from forty to three hundred and fifty miles. Its average elevation is nearly 12,000 feet. Twenty of its peaks attain an altitude of more than 19,000 feet, the highest of which, Aconcagua, is 22,422 feet in height.

8. Mountain-System of Parime.—This system consists of a group of high and rugged mountain-ranges, irregular in

² *Sierra*, a Spanish word, meaning a saw; a term used to describe a notched mountain ridge.

outline, which traverse the elevated region embraced by the Orinoco and Amazon Rivers; among them are the Sierras Acaray, Parime, and Pacaraima. North of the Parime system lies the coast-chain of Venezuela. Mount St. Martha, the highest peak, reaches an elevation of 19,000 feet.



PEAK OF ACONCAGUA.

9. **Brazilian System.**—Like the Parime chain, the Brazilian Mountains form an isolated group, extending from Cape St. Roque to the river La Plata, at varying distances from the coast, and possessing an average height of 3200 feet. From one of these ranges rises the peak of Itambe, nearly 6000 feet high.

EUROPEAN SYSTEMS.

10. **Scandinavian System.**—This chain, comprising the mountains of Norway, Sweden, Lapland, and Finland, extends along the entire coast of Norway for the space of one thousand miles. The highest peak is Ymesfield, 8543 feet high.

11. **British System.**—This is one of low elevation, the highest summit being Ben Nevis, in Scotland, which attains an altitude of 4405 feet. Its chief component ranges are the Grampians in Scotland, the Cumberland Mountains in England, and the Cambrian in Wales, together with those of Ireland. In England the culminating point is Sca Fell, which attains an altitude of 3166 feet above the sea.

12. **Sardo-Corsican System.**—This system embraces the mountains of the islands of Sardinia and Corsica. It extends in the direction of the length of the two islands, being broken by the Strait of Bonifacio.

13. **Spanish System.**—This includes all the mountains of Spain and Portugal, together with those of France south of the Garonne. Its component chains are the Pyrenees and Cantabrian ranges, the Sierra Morena, the Mountains of Castile, and the Sierra Nevada, which terminates in the frowning rock of Gibraltar. The great chain of the Pyrenees extends from the Bay

of Biscay to the Mediterranean Sea, forming a natural rampart between France and Spain. Its principal crest is a wavy line, having an average altitude of 7000 feet.

14. **Alpine System.**—This is the most complex of all the European mountain-systems, and, with its eastern and western extensions, constitutes the main axis of the continent. From Mont Blanc this chain extends southward to Genoa, westward through the Cevennes Mountains, and eastward through Austria.

Here its extensions, the Balkan and Carpathian ranges, enclose the valley of the Danube. The Apennines and Pindus ranges are spurs of this system. Many geographers consider the Caucasus Mountains also as belonging to it.

Mont Blanc, Monte Rosa, and the Matterhorn are the highest peaks, the first named being 15,780 feet high.

15. **Caucasian System.**—The Caucasian chain, stretching from the Black to the Caspian Sea, separates Europe from Asia. It is seven hundred miles long, and has a breadth varying from sixty to one hundred and twenty miles. Numerous spurs branch off from the main chain, whose highest summit is Mount Elbrooz, more than 18,500 feet above the ocean.

16. **Ural System.**—This chain is a narrow highland dividing Europe from Asia. It presents but few of the usual features of a mountain-system. The Ural Mountains extend northward to the Arctic Ocean, a distance of nearly two thousand miles. They are rugged and precipitous, and abound in rich deposits of gold and copper.

MOUNTAIN-SYSTEMS OF ASIA.

17. **Himalaya System.**¹—This system constitutes the main continental axis of Asia. In general features it resembles the



THE ALPS, SWITZERLAND.

Alpine system, but it is far greater in extent. Beginning at Asia Minor on the west, its minor divisions reach eastward to the

¹ This chain, the loftiest in the world, abounds with scenery surpassingly magnificent and sublime. Gorges and abysses are here beheld so deep and narrow, and overhung by precipices of such tremendous height, that the

rays of only a vertical sun can pierce the thick gloom that shrouds their depths; while more than forty peaks, uprising from the spurs of this mighty chain, lift their snowy tops to altitudes exceeding 20,000 feet.

Pacific Ocean, a distance of five thousand miles. The ranges of the Hindoo Koosh, with their western extension, the Taurus Mountains, form a compact network of mountain ramparts, which extend to the eastern border of Afghanistan, where they separate into a number of minor systems.



HIMALAYAS. SNOWY RANGE.

The Himalaya and Kuen Lun Mountains, with their colossal peaks and transverse spurs, extend to the southeast for a distance of fourteen hundred miles, and their prolongations, under various names, reach to the China coast. For hundreds of miles this giant system forms an unbroken barrier 20,000 feet high. More than twenty of its peaks reach an altitude of 27,000 feet. Mount Everest, the culminating peak, is 29,002 feet above the sea-level.¹

18. Minor Systems.—The Altai System includes the Altai, Yablonoi, and Stanovoi Mountains, with their numerous spurs and plateaus. The Himalaya and Altai systems enclose the great interior basin of Asia, which is traversed throughout by numerous lofty ranges. Of the latter, the Thian Shan Mountains are the most notable.

The Asia Minor System, which may be considered the western extension of the Hindoo Koosh Mountains, comprises the rugged ranges of the Taurus, Anti-Taurus, and Elborz Mountains. Spurs from this system extend southward along the Red Sea and the Persian Gulf, enclosing the Arabian Peninsula. The volcanic peak of Demavend, 20,000 feet in height, is the culminating point.

The Assam, or Farther Indian System, includes the highlands of the Farther Indian Peninsula, and the chain of mountains extending through the Sunda Islands and New Guinea. This chain is at present the greatest seat of volcanic activity on the globe.

The ranges of Hindoostan are usually considered spurs

of the Himalaya system. Of these the Eastern and the Western Ghats are the most important, as they enclose the plateau of the Deccan, which forms the peninsula.

19. Australian System.—The main ranges of Australia are the Blue Mountains, which extend southward from Cape York into Tasmania, skirting the coast at distances varying from fifty to one hundred and fifty miles from the sea. This chain, though of moderate elevation, rises, in Mount Kosciusko, to the altitude of nearly 7200 feet. A lower range, called the Darling Mountains, is parallel to the west coast of Australia.

This mountain-belt is continued with the same bold features through New Guinea, where the crests are covered with perpetual snow. Lofty mountain-ranges also run through the island of New Zealand, culminating in Mount Cook, 12,349 feet above the sea.

MOUNTAIN-SYSTEMS OF AFRICA.

20. Atlas System.—The Atlas Mountains consist of several ranges extending westward between the Mediterranean and the Great Desert, from Tripoli to the Atlantic. The peak of Jebel Tedla, in Morocco, towers above the snow-line, having an altitude of 13,000 feet.

21. Guinea System.—In Western Africa a mountain-system extends through the whole of Guinea, stretching along the coast from Senegambia to Damara Land. Beginning with the coast-range of Sierra Leone, it is prolonged in the Kong and Cameroons Mountains. This system comprises a number of irregular ranges, concerning which little is known. The Cameroons Mountains are probably the highest of the system.



TABLE MOUNTAIN.

22. Cape System.—The surface of Southern Africa consists of a series of sandstone terraces, intersected by granite rocks. These rise, one above the other, to elevations of 2000, 4000, and 6000 feet above the sea. The steps of these terraces consist of rocky ranges and flat-topped mountains, which form the Cape system of highlands.²

¹ The unsurveyed peak T 45 is thought to be a few feet higher than Mount Everest. The British Indian Survey has been engaged for a number of years in measuring the altitudes of the higher peaks of the Himalaya Mountains. With the exception noted, none higher than Mount Everest has been discovered.

² The first of these ranges, called the Zwellendam, about twenty miles inland from the Cape coast, rises in Table Mountain to the height of thirty-six hundred feet. Behind this is the Black range, and beyond this are several other ranges, which attain in the Snow Mountains the elevation of ten thousand feet.

Parallel to the African coast, lofty mountain-chains traverse the adjacent island of Madagascar for the space of one thousand miles. The three principal ranges vary in altitude from 8000 to 12,000 feet above the ocean.



PASS OF THE VIA MALA, RHÆTIAN ALPS, SWITZERLAND.

23. Eastern System.—Beyond the Snow Mountains the Eastern system begins, following the coast of Zanzibar in irregular ranges. Its highest peaks are Kilimanjaro and Kenia, each more than 18,500 feet high. North of the equator the various ranges of this system merge into the highlands of Abyssinia. This system is the main axis of the continent.

The elevated table-land of Abyssinia is flanked and traversed by rocky ramparts and mountain-barriers, cleft by deep and perilous chasms. The chief ranges are the Samen and the Taranta, which extend northerly between the branches of the Upper Nile and the Red Sea.

VALLEYS AND PASSES.

24. Valleys are depressions of land occurring in mountainous districts. They are simply local, however, for many valleys have a greater elevation above the ocean-level than some mountain-ranges. They may be either *longitudinal* or *transverse*. The former lie *between* parallel mountain-ranges; the latter cut *through* them at various angles, forming *passes*.

One of the finest examples of the former in the Western Continent is the fertile valley between the Blue Ridge and the Alleghany Mountains. Another is the Valley of the Sacramento and San Joaquin Rivers, which extends for a distance of

five hundred miles between the Sierra Nevada Mountains and the Coast Range of California.¹

25. Passes.—Transverse valleys are, for the most part, natural highways leading across mountain-chains through the depressions and gaps of the ranges. They are then termed *passes*. In many instances they are broad thoroughfares of easy access and lofty elevation.

Such is the South Pass, one of the great gateways of commerce and travel between the Mississippi Valley and the Pacific. This remarkable gap is twenty miles wide, and has an altitude of 8100 feet above the sea.²

26. Depressions below the Sea-Level.—Various portions of the earth's surface are below the level of the sea.

The Basin of the Caspian Sea is a remarkable instance of this kind. It contains about 120,000 square miles, nearly all of which is below the sea-level. The surface of the Caspian Sea is eighty-four feet below that of the Black Sea, with which it is thought to have communicated in former times.

The Valley of the Jordan River, though less extensive, is the deepest depression at present known. The surface of the Dead Sea, according to the most recent measurements, has an average depth of thirteen hundred and two feet below that of the Mediterranean Sea, from which it is less than fifty miles distant.

The Schotte of the Great Desert form a chain of depressions situated south of the Atlas Mountains. In character, the Schotte are salt marshes and lagoons. They are in no place more than one hundred feet below the sea-level. The Bahr Assal, near the Gulf of Aden, is a more notable depression. It is nearly six hundred feet below the sea-level.

Death Valley, a similar depression in the United States, extends along the eastern base of the Sierra Nevada Mountains. It is the "sink" of the Amargosa River, and is nearly four hundred feet below the sea-level. The Southern Pacific Railway crosses the "sink" of the San Felipe River at a point two hundred and sixty-one feet lower than mean tide-water.

27. Utility of Mountains.—Mountains form an important part of the mechanism of the globe. As we rise from the sea-level, the temperature uniformly decreases, until, at an altitude of a few thousand feet, we reach a region of perpetual snow.

Mountains thus become the great natural refrigerators of the globe, condensing the vapors of the atmosphere, causing rains to descend upon the land, and giving birth to the mighty rivers of the earth.

Mountain-chains attain their greatest height in tropical regions, where, at the sea-level, the heat is most intense. Hence, along their lofty sides every variety of climate is found, each with its peculiar type of animal and vegetable life.

Mountains are likewise the great depositories of the minerals and precious metals so essential to the civilization and comfort of man. Their rugged barriers have ever constituted natural boundaries between different races, and in all ages their fastnesses have been the asylum of Liberty.

¹ In Europe a remarkable instance is seen in the Canton of the Valais, Switzerland. Bounded on the south by Mont Blanc and Monte Rosa, and on the north by the Bernese Alps, this valley, varying in breadth from two furlongs to three miles, stretches between its rocky barriers for nearly a hundred miles to Monte Furca, whose glaciers are the headwaters of the Rhone River.

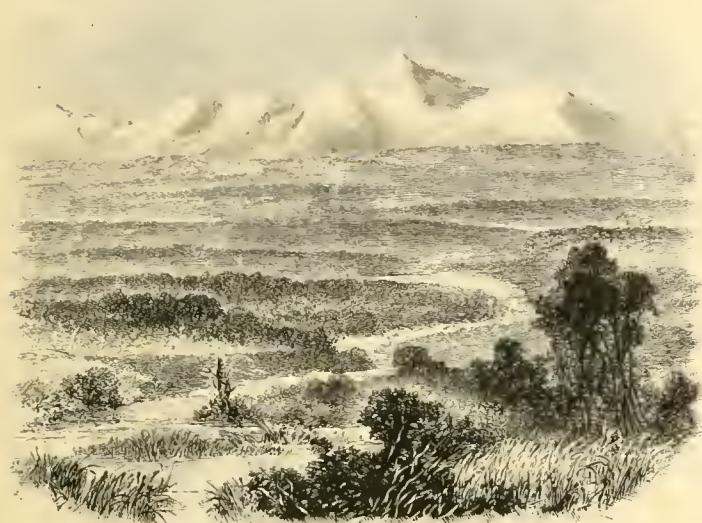
² The physical features of valleys are different from those of passes, for

the latter are usually nothing more than narrow gorges of tremendous depth. The Vale of Cashmere, walled in by the ranges of the Himalaya Mountains, is accessible by seven such passes. One of these is the valley of the river Terek, where the road winds along the brink of appalling precipices. Above, the mountain-cliffs are so lofty, close, and overhanging, that the frightful chasm, even at noonday, is darkened by a twilight gloom.

CHAPTER IV.

PLATEAUS.

1. **A Plateau**, or table-land, is a vast elevated region, two thousand feet or more above the sea-level. It may be diversified by hills or traversed by mountains; but a predominance of level expanse is its characteristic feature.



A PLATEAU.

The Eastern Continent abounds with plateaus, and nowhere else are they so numerous, elevated, and extensive as in Asia and Africa. In the former the mountains and table-land cover five-sevenths of the surface, and in the latter two-thirds. In the Western Continent only one-third of its area is occupied by these elevated tracts.

The height of plateaus increases with the elevations of the mountains above the sea-level. The loftiest plateaus are found in equatorial regions, where the highest mountain-chains likewise occur.

PLATEAUS OF NORTH AMERICA.

2. **Eastern Plateau of the Rocky Mountains.**—This region consists of a belt of land skirting the eastern face of the Rocky Mountains. It extends from about 30° north latitude to the Arctic Ocean. The mean height of the plateau is four thousand feet; but the western portion, or upper plateau, is much higher; for the Laramie plains have an altitude of six thousand feet. It is commonly known as "The Plains."

Throughout its entire extent "The Plains" is covered with bunch grass, upon which millions of cattle subsist. Dense growths of cotton-wood border the river bottom-lands, but otherwise the whole region is destitute of trees.¹

3. **Great Western Plateau.**—This region, commonly known as the "Basin Region," lies between the Rocky Moun-

¹ This region was formerly called the "Great American Desert." It is now known to be more than ordinarily fertile, wherever water can be obtained for irrigation. It comprises some of the most fertile parts of Texas and the Indian Territory.

² The table-land of Tenochtitlan is an oval expanse, in the midst of

tain and the Cascade and Sierra Nevada ranges, stretching from British Columbia to the Gulf of California. It comprises three great divisions—namely, the *Great Interior Basin*, the *Plains of the Columbia*, and the *Colorado Plateau*.

The **Great Interior Basin** has a breadth of five hundred miles, and an altitude of about 5000 feet. It is shut in on all sides by mountains, and has its own system of lakes and rivers, none of which reach the ocean. It is traversed by numerous parallel ranges of mountains which rise abruptly from the sterile, alkaline plain. There are but few fertile spots, and these are along the river valleys.

The **Plains of the Columbia** are north of the Great Interior Basin. They constitute the northern part of the Basin Region, and are drained by the Columbia River.

The **Colorado Plateau** is situated west of the Wasatch Mountains, and embraces all of the region drained by the Colorado River and its tributaries. The southern part is drained by the Gila River, and is called the Gila Desert.

4. **Mexican Plateau.**—Beyond the Southern plateau begins the Mexican plateau, which extends southeasterly to the Isthmus of Tehuantepec. Its chief table-lands are those of Chihuahua and Anahuac.

The table-land of Chihuahua is a desert region, having an elevation of from 4000 to 6000 feet above the sea. That of Anahuac, on the contrary, is for the most part fertile, and has a



VIEW IN THE GREAT INTERIOR BASIN.

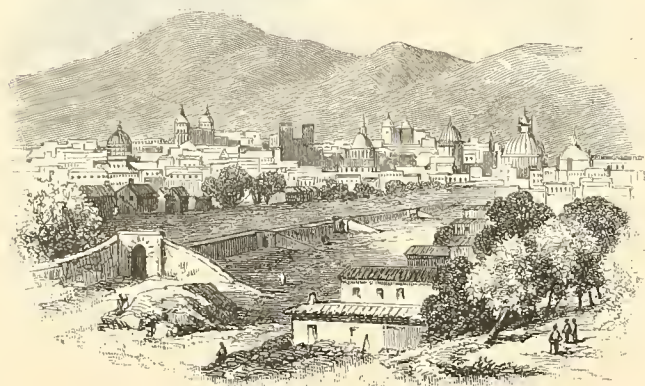
greater altitude, varying in height from 6000 to 8000 feet. It is 360 miles wide.²

5. **Plateau of Central America.**—This embraces the minor plateaus of Guatemala, Honduras and Nicaragua, and Costa Rica. That of Guatemala consists of a vast, rolling, and fertile plain, rising above the sea to the height of 5000 feet.

which stands the city of Mexico. Two mountain-passes, five hundred miles apart, lead from this lofty plateau to the Gulf of Mexico—one at Jalapa, near Vera Cruz, and the other at Saltillo, west of Monterey. Through the first of these the daring band of Cortez marched to the conquest of Mexico. Both defiles were forced by the American army in the war with that country.

PLATEAUS OF SOUTH AMERICA.

6. **Table-Land of Colombia.**—The highlands of Colombia consist of the plateaus of Bogota and Popayan. The former, which surrounds the city of Bogota, is a level plateau having an altitude of nearly 9000 feet. The city of Popayan is situated in the latter.



CITY OF CUZCO.

7. **Plateau of Ecuador.**—Directly beneath the equator is the plateau of Ecuador, with an average altitude of 10,000 feet above the ocean. It is girded by a rampart of volcanoes. Nowhere else in the Andes are found such gigantic mountain-masses as rise on the east and west of this basin. This plateau is covered throughout the year with abundant vegetation.¹

8. **Plateau of Peru and Bolivia.**—This elevated tract extends for more than 1000 miles southward from the mountain-knot at Cuzco. It is remarkable for its vast size. Its area is 150,000 square miles, and its altitude is more than 12,000 feet.²

The southern part of this region is a desolate tract swept by cold winds from the summits of the Andes. With the exception of a scanty covering of coarse grass, it is destitute of vegetation.

9. **Plateau of Brazil.**—The plateaus of Eastern South America occupy more than half of the empire of Brazil, and comprise an area of 1,510,000 square miles. They have a mean altitude of 3200 feet above the sea.

The greater part of this immense tract has an undulating surface, covered with dwarf trees and shrubs; but it embraces also extensive regions covered with dense forests.

PLATEAUS OF EUROPE.

10. **Europe** is almost destitute of plateaus. The most important is that of the Spanish Peninsula, a lofty table-land, traversed by several mountain-ranges. Portions of this region are destitute of trees, while others are rich and productive, abounding with grains and fruits. This plateau has a general altitude of about 2500 feet above the sea.

¹ Within this plateau, at an elevation of nearly 10,000 feet, is the city of Quito, the capital of the second Peruvian monarchy. It contains a population of 23,000, and vies in splendor with the cities of the sea-board in either hemisphere. It is situated on the side of the volcano Pichincha, which towers 16,000 feet above the sea. Many monuments of the ancient Incas still exist throughout this region.

² The city of Potosi, situated in this region, is said to be the highest city in the world, being 13,350 feet above the sea. At nearly the same height

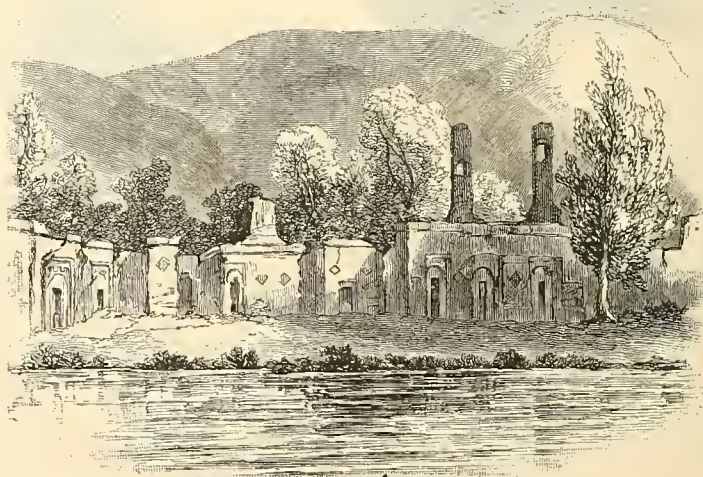
PLATEAUS OF ASIA.

11. **Plateau of Asia Minor.**—This plateau, lying between the ranges of the Taurus and Anti-Taurus, is rugged and mountainous. Its surface is diversified with numerous salt lakes, separated by fertile valleys. It is prolonged eastward into Armenia, between the Black Sea and the Caspian Sea, where its elevation is greatest.

12. **Plateau of Arabia.**—Arabia comprises a series of arid plains, having an altitude varying from 3000 feet in the northeast to more than twice that height in the southwest. The general level is broken by short and irregular ranges, which enclose fertile and well-watered valleys. A barren tract known as the Syrian Desert occupies a large area in the central part.

13. **Plateau of Persia.**—This region, called also the Plateau of Iran, varies in height from 2000 to 3500 feet above the sea. In the south and west it descends by slopes and terraces to the Arabian Sea and the Persian Gulf. The northern part is a vast salt desert.

14. **Basin Region of Central Asia.**—Central Asia is enclosed by the Altai and Yablonoi Mountains on the north and the Himalaya Mountains on the south. None of its rivers reach the sea, and the whole expanse consists of salt marshes alternating with stretches of desert land. In many places it is covered with coarse grass.



RUINS OF TEMPLES ON THE ISLAND OF TITICACA.

The **Desert of Gobi** is a rainless region having an elevation of over 4000 feet. Within this desert is the Han Hai, or Dry Sea, a vast plain of shifting sand, rolled into waves and billows by the winds.

15. **Plateau of Thibet.**—Between the Kuen Lun and the Himalaya Mountains is situated the Plateau of Thibet. This

is the city of La Paz, bounded on the southeast by the snowy crests of the Illimani ranges. One of the most interesting features of this region is Lake Titicaca, more than half the size of Lake Erie. This lake is in some places 700 feet deep. It is studded with numerous islands, from the largest of which it takes its name. Here, according to the legends of the Peruvians, Manco Capac, the divine founder of their empire, first appeared; and the ruins of temples are still visible upon the sacred island. Similar ruins are found in many other localities in Peru.

plateau is, without doubt, the highest inhabited region in the world, having, according to recent surveys, an average altitude of nearly 15,000 feet above the sea.¹

16. Table-Land of India.—This region, enclosed by the Vindhya Mountains and the Eastern and Western Ghats, includes the plateaus of the Deccan and of Mysore. Rising from the high plains of Malwa, this plateau stretches southward to the uplands of the Neilgherries. The table-land of the Deccan, on the north, has an altitude of nearly 2500 feet. Southward the plateau of Mysore reaches an altitude of 5000 feet.

PLATEAUS OF AFRICA.

17. Africa may be considered an immense plateau fringed by a narrow strip of lowland coast. The northern part has an elevation of 1500 feet; the eastern and southern parts are much higher, reaching an average of 7000 feet or more in height.

The **Abyssinian Plateau** consists of a rugged highland 7000 feet high. It is traversed by lofty mountain-ranges and watered by numerous streams. Grains and grasses are abundant, and in many localities there are dense forests.

18. Plateau of Central Africa.—In the eastern part of Central Africa is the highest plateau of the continent. It is traversed by ranges of snow-capped mountains, and contains, next to that of North America, the largest lake system in the world. Most of the large rivers of Africa have their sources in this region.

19. South Africa.—This region is a plateau of variable altitude—highest towards the east. Its average elevation is about 5000 feet. It includes the Kalahari Desert, an extensive region generally destitute of vegetation. The large inland basin, of which Lake 'Ngami is the lowest depression, is also a part of this plateau.

Cape Colony, the southern extremity of this plateau, is clothed with abundant vegetation during the season of rains, but parched and desolate in time of drought.



SECTION OF SOUTH AFRICA, SHOWING THE CENTRAL BASIN.

20. Utility of Plateaus.—In respect to their use, plateaus possess advantages similar to those of the great mountain-ranges of the globe. Although they are inferior in height, yet on account of their great extent they subserve the same ends.

CHAPTER V.

PLAINS.

1. Plains are extended regions, generally level, but sometimes diversified with hills and valleys. They rise but little above the sea, and in places are even lower. They do not exceed the altitude of two thousand feet—all higher expanses being termed table-lands.

Plains have received different names from their peculiarities. Thus, plains abounding in grass, but destitute of trees, are termed *Pampas*, *Llanos*, *Steppes*, and *Prairies*; those covered with forests are called *Silvas*.

¹ Scattered throughout the valleys which traverse it are thousands of mountain lakes, among them the sacred lakes of Manasarowar and Rewan,

NORTH AMERICA.

2. Great Central Plain.—This immense expanse extends a distance of about five thousand miles from the Arctic Ocean to the Gulf of Mexico—the land rising from the northern shores to the sources of the Mississippi, and thence descending southward to the Gulf. It is bounded on the west by the Rocky Mountains, while the Appalachian Mountains form its eastern



THE PLAINS.

limit. No part of this vast tract is elevated more than sixteen hundred feet above the sea, and a very large portion rises no higher than three hundred feet.

Near the source of the Mississippi the plain has its greatest altitude. The Height of Land, a belt of upland stretching from the great lakes towards the Rocky Mountains, forms an irregular water-shed, which divides the Great Central Plain into two principal basins. These are the Basin of the Mississippi and the Arctic slope, including that of the St. Lawrence. The waters of the first flow into the Gulf of Mexico; those of the latter, into the Arctic Ocean and the bays and gulfs of the North Atlantic.

The rich valley or basin of the Mississippi, throughout nearly its whole extent, possesses a soil of boundless fertility. Nearly all of the eastern part was once overspread by forests, many of which still remain. The western plains are destitute of timber, except along the river bottoms.

The Hudson Bay Basin, in size, rivals that of the Mississippi. It lies north of the Height of Land. It is a cold and dreary region, filled with swamps and lakes, and traversed by numerous streams.

The Laurentian Lake Basin lies south of Hudson Bay. It embraces the great lakes, whose surplus waters are discharged into the St. Lawrence River.

3. Atlantic Plain.—From the Gulf of St. Lawrence to the former 15,000 feet above the sea-level. Near these lakes, at an altitude of 17,000 feet, are found the fossil remains of the elephant and the rhinoceros.

Gulf of Mexico the Alleghany Mountains gradually descend eastward to the Atlantic, forming an upper and a lower plain.

The upper plain is higher, and diversified with hills. At the junction of the two plains is a well-defined terrace, on which most of the important cities of the Atlantic plain are situated.

The lower plain does not rise higher than about one hundred feet above the sea, and from Long Island to Cape Fear River it scarcely exceeds fifty feet in altitude. Most of the lowlands are overflowed, and covered with swamps.

SOUTH AMERICA.

4. **Llanos of the Orinoco.**—This region, stretching from the Mountains of Caraccas to the mouth of the Orinoco, and thence southward to the equator, comprises an area of 160,000 square miles. The entire expanse is less than two hundred feet above the sea, and is so flat that the motion of its rivers is hardly perceptible: the slightest wind contrary to the current of the Orinoco raises its waters and turns back the current of its tributary streams.

During the rainy season vast tracts are flooded, and after the subsidence of the water their surface is quickly covered with verdure. But when the dry season returns they are soon transformed into deserts, and nothing remains of their former brilliant vegetation except along the borders of stagnant pools.



SILVAS OF BRAZIL.

5. **Silvas of the Amazon.**—The interior of South America is an immense plain, traversed by the Amazon, and extending from the Andes to the Atlantic. It has an area of more than

¹ This plain consists of two great divisions—the *northern*, comprising the Pampas of Parana and a desert of sand, termed El Gran Chaco, and the *southern*, which, extending to the Strait of Magellan, includes the Pampas of Buenos Ayres and Patagonia. This immense tract is not, however, uniform in its character, but may be divided into several districts, differing in climate and productions. That part of this plain which is west of Buenos Ayres produces clover and thistles—the latter of such enormous size as to form an impenetrable thicket, sometimes hundreds of square miles in extent. A large part of this plain is inundated by the annual rains, and multitudes of cattle perish by these floods. The drought that sometimes succeeds is

2,000,000 square miles. Its name is derived from the *silvas*, or forests which lie between the Amazon and the Orinoco.

6. **The Pampas.**—South of the Silvas are the Pampas. They are situated between the Andes and the Atlantic, and extend as far south as Terra del Fuego.¹

The Pampas are almost perfectly level, and have scarcely a stone upon their surface. They are destitute of trees, and have but little water. They are covered with a tall, coarse grass, which furnishes food to millions of wild cattle.

Beyond the Colorado River the Pampas of Patagonia extend southward to the extremity of the continent. This region, on account of its severe climate, is generally sterile. Intersected by a few streams and swept by cold winds, these plains yield but a scanty vegetation.²

7. **Pacific Coast-Belt.**—On the western coast of South America the Andes slope precipitously to the Pacific, forming a narrow belt of lowlands from fifty to one hundred miles wide. The northern and southern portions of this region are fertile; but in the central part it is a rainless district. Fruitful valleys here border the mountain-streams, but these are in most instances separated by great sandy wastes, of which the Desert of Atacama, in Chili, is an example.

EUROPE.

8. **Great Northern Plain.**—This region comprehends nearly two-thirds of Europe, and extends from the Pyrenees on the south-west to the Ural Mountains on the east.

The western part embraces the fertile plains of France, Belgium, the Netherlands, and the German lowlands. The eastern, and larger, division is called the Sarmatian plain. It extends from the Baltic Sea to the Ural Mountains. It is, however, interspersed with swamps and wide expanses of sterile soil. The river Prypet flows towards the Dnieper through a swamp having an area of two thousand square miles.

The western coast of Denmark is one unbroken level of marshes; and a part of Northern Germany, from Lower Silesia to Hanover, consists of *landes*, or sandy tracts, generally overgrown with pine, or else covered with heath. Similar sandy plains are found in France at the base of the Pyrenees.

The Steppes of Russia form a vast treeless plain, hundreds of miles long, covered with rank, coarse grass. This plain has a rich, black soil, producing the wheat that now makes Russia the granary of the Levant.³

The Great Northern Plain is an almost unbroken level. From the Ural to the Carpathian Mountains—a distance of fifteen hundred miles—there is scarcely an inequality in the surface. Its greatest elevation, the Valdai Hills, nowhere exceeds eleven hundred feet in altitude. Were the ocean to rise one thousand feet, the whole plain, except the crest of the Valdai Hills, would be submerged.

equally fatal. The fires that at times sweep through the dry grass of the pampas are also terribly destructive.

² In 1884–5 the region known as Patagonia was divided between the Argentine Republic and Chili. During the surveys several large and fertile valleys were discovered. The greater part of the region is barren and swept by cold winds.

³ Thousands of mounds, or barrows—the sepulchres of the dead—everywhere diversify its surface. Similar mounds are found throughout the steppes and vales of Tartary. They are also numerous on the western coast of North America.

9. Southern Plains.—The principal lowlands of Southern Europe are the plains of Hungary and the valley of the Lower Danube. The great levels of Hungary, termed *Puszta*, are highly fertile. The districts of the Lower Danube are fertile, but swampy. They are especially productive along the banks of the streams.

ASIA.

10. Siberian Steppes and Plain.—Extending beyond the Ural Mountains into Asia, the great northern level stretches eastward to the Pacific Ocean, constituting the Siberian Plain. It is an immense expanse, traversed by sluggish streams, and unbroken except by almost imperceptible undulations.

For thousands of miles these undulations succeed one another with such sameness that the traveller can hardly recognize any progress by the change of scenery.



STEPPIES OF SIBERIA.

In the spring the steppes are covered with rich grass, which affords pasture for the numerous herds belonging to the nomadic hordes that roam over this region. But the droughts of summer change the grassy tracts to deserts, and the storms of winter turn them into snowy wastes.¹

The great northern levels of Europe and Asia are to be regarded as one immense plain, whose continuity is broken only by the Ural Mountains. Its area is estimated at not less than 4,500,000 square miles.

11. Lowland of China.—China consists, in the eastern part, of an alluvial plain, more than 200,000 square miles in extent. It is extremely well watered by rivers and canals.

12. Plains of Farther India.—Between China and the Brahmaputra lies the Peninsula of Farther India. The fine and rich soil constantly brought down by the streams which

traverse it has transformed the river-valleys into wide plains of wonderful fertility.

13. Plain of Hindoostan.—The Plain of Hindoostan stretches southward about fifteen hundred miles from the base of the Himalaya Mountains. The finest portion of this plain is the alluvial region watered and fertilized by the Ganges and its tributaries. The southern part is called the Sunderlands. It is so low as to be overflowed by the tide.

AFRICA.

14. The Sahara.—The Great African Desert is a vast barren tract extending from the shores of the Atlantic to the Valley of the Nile—a distance of about three thousand miles. It is situated between Soudan and the Atlas Mountains on the north. The area of this great expanse is estimated at 2,700,000 square miles. A small tract south of the Atlas Mountains is below the sea-level. The southern part is traversed by mountain-spurs and broad plateaus.

The surface of the Sahara possesses a varied character. Large areas are wastes of shifting sands, without water and vegetation; others are gravelly plains, interspersed with low, bare rocks, and producing a growth of small shrubs and coarse grass. In various places, however, water rises to the surface, forming fertile tracts, termed *oases*.²

The Nubian Desert, or Egyptian Soudan, may be regarded as prolonging the plain of the Sahara to the Red Sea, since these desolate wastes are separated only by the Nile River, which flows through the narrow valley that traverses them.

The Sahara may be considered, therefore, the western division of the desert zone, which stretches from the Atlantic to Egypt, and is thence continued northeasterly through Asia.

15. The Congo Basin.—This extensive region of plains, explored a few years since by Livingstone and Stanley, comprises the richest and most fertile part of Africa.

The basin of the Congo River is the largest river basin in the Eastern Continent, and is nearly, if not quite, equal in size to that of the Mississippi River. From the high lake region, on its eastern boundary, to the Atlantic coast, the whole region is well watered and covered with a profuse vegetation.³

16. The Central Plain.—This region, which includes Soudan, embraces large areas, some of which are fertile and well cultivated; others are sandy wastes, interspersed with salt lakes, and having quarries of rock-salt, which are among the principal resources of the country.

In Senegambia and Guinea a rich alluvial belt of lowland extends along the sea-coast, wonderfully productive, but possessed of a climate deadly to the white race.

17. Australian Plain.—The interior of Australia is an inland basin, having an average elevation of but a few feet above the sea-level. In places it is traversed by short mountain-spurs, and interspersed with salt marshes. In summer it becomes a sterile waste, swept by winds as hot as the African simoom.

¹ Nothing can exceed the dreariness and desolation of the Siberian plain. The parallel of 62° north latitude is the limit of the grain-growing region. Beyond this there are forests of fir and spruce, intermingled with swamps and lakes. The forests at last fail, and nothing exists but an immense expanse of morass, bog, and moss, called the Tundra, which extends to the shores of the Arctic Ocean. The swampy character of the Tundra is due to the overflow of the rivers of the Arctic slope.

² Fezzan, one of the largest oases, contains 100,000 inhabitants, whose principal food is derived from the forests of the date and palm with which this region abounds. The surface of the oasis is generally below that of the surrounding desert.

³ The interior of the Congo Basin is inhabited by half-civilized tribes of people, who devote themselves chiefly to their herds of cattle. In 1884 this territory was organized as the Congo Free State.



EXPLANATION.

ALTITUDES.	OCEAN DEPTHS.
Below Sea Level.	Sea Level to 100 fathoms.
Sea Level to 600 feet.	100 to 1,000 fathoms.
600 feet to 1 mile.	1,000 " 2,000 "
1 to 2 miles.	2,000 " 3,000 "
2 to 3 miles.	3,000 " 4,000 "
3 to 4 miles and over.	Over 4,000 "

Longitude West 90 from Greenwich 60 30 0



REVIEW AND MAP QUESTIONS ON THE CONTOUR AND RELIEF OF THE LAND.

CONTINENTS.

How are the two great continents designated?
What other masses of land are found in the high northern and southern latitudes?
What great island is there which is sometimes called a continent? and where is it situated?
Which continent extends farthest south?
Which farthest north?
Which is the larger of the two continents?
Between what parallels of latitude does the Eastern Continent lie?
Between what meridians?
In what direction does it extend in its greatest length?
What are its grand divisions?
How are these situated in reference to the equator?
In what direction does it run in its greatest length?
Between what parallels of latitude does it lie?
Between what meridians?
Which of the great divisions of the land has the most extensive coast-line compared with its area?
Which the least?
What form do the great masses of land generally assume towards the south?
In what regions are the continents broadest?
Are both the continents nearly divided by the sea?

ISLANDS.

Point out on the map examples of continental islands in the different oceans and seas.
What are oceanic islands?
In what ocean are they most numerous?
Trace on the map the great chains that exist in the Pacific Ocean.
Point out the three great belts of volcanic islands.
Which is the most northerly volcanic island?
Point out the volcanic islands of the Atlantic Ocean.
What is the nature of the Aleutian Islands?
Within what limits are coral islands found?
In what oceans do they abound?
Point out the most remarkable groups of atolls.
Where are the most remarkable barrier reefs situated?

MOUNTAINS.

Show in what direction the mountain-chains of a continent usually run.
Point out on the map instances of these in both continents.
On what side are the mountain-slopes most abrupt?
Which of the two continents has the largest chain?
Name the mountain-systems of North America.
Describe the Rocky Mountain system.

Describe the Appalachian system.

Name the South American systems.

Describe the Andes.

Between what parallels of latitude are the Rocky Mountain and Andean systems included?

Mention the mountain-systems of Europe.

What mountains separate Europe and Asia?

Name the mountain-systems of Asia.

What important ranges are north of the Hindoo Koosh?

What are the mountain-systems of Africa?

Where are the Atlas, Cameroons, and Kong Mountains situated?

What high range is in Eastern Africa?

What island east of Africa has a great range of mountains?

What mountains are found in Australia?

How are they situated?

Which is the highest mountain on the globe?

Point out on the map the chief regions below the sea-level.

TABLE-LANDS, OR PLATEAUS.

Which of the two continents is most remarkable for its plateaus?
Name the plateaus of North America.
Where are they situated?
Name the plateaus of South America.
Which is the highest?
What plateau is found in Europe?
Name the table-lands of Asia.
Which is the largest?
Which is the highest?
Which continent has the highest plateau?

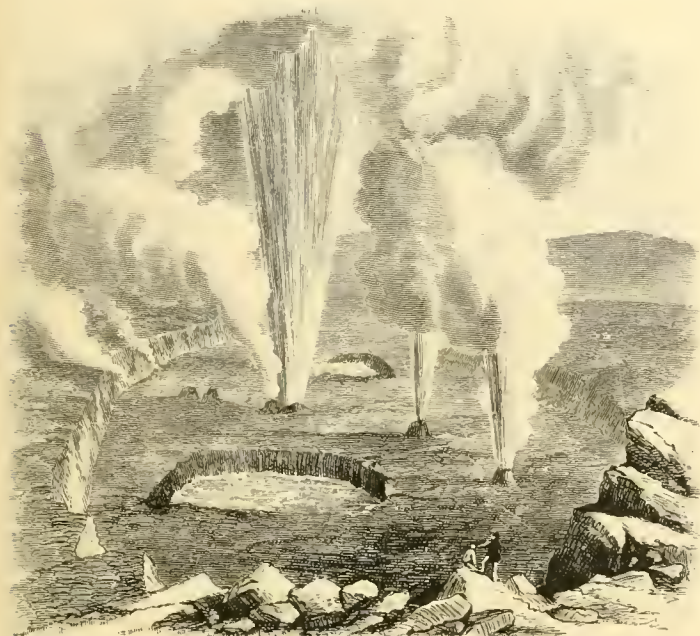
PLAINS.

Which continent is distinguished for its plains?
Name the plains of North America.
Describe the Atlantic Plain.
Mention the plains of South America.
Where are the Llanos situated?
What is their character?
Describe the Silvas.
Describe the Pampas.
Mention the plains of Europe.
Where are the Steppes of Russia?
Where is the plain of Hungary?
Name the plains of Asia.
Describe the Siberian Plain and Steppes.
What plains has Africa?
Where is the Sahara, or Great Desert?
What is the nature of its soil?
What is its altitude above the sea?

CHAPTER VI.

VOLCANOES.

1. A **Volcano** is an opening in the earth's crust from which steam, various other vapors, and floods of molten rock, called *lava*, are ejected. In most instances a conical mountain, built from the ejections, surrounds the volcano. At the top of the mountain is a bowl-shaped depression known as the crater.



KILAUEA, HAWAII.

2. **Craters.**—Volcanic craters vary in size from a few rods to several miles in diameter. In a few instances craters are depressions in lofty table-lands. The walls of the crater are generally rent by immense fissures, through which the floor of the crater can be reached. This floor, in active volcanoes, is the seat of their energy.

In the volcano of Kilauea in Hawaii, one of the most remarkable in the world, the great crater is a vast depression, three miles long and one mile broad. Its surface is more than one thousand feet below the plain. The volcanic action is concentrated in a space about two miles long, occupied by numerous smoking cones and lakes of lava.¹

3. **Volcanic Products.**—Lava varies much in its composition and structure. It is chiefly composed of a few minerals;

¹ When the crater was visited in 1823 there were two lava-lakes, the largest of which was 1190 yards long. Eleven years afterwards they were still in existence, and presenting the appearance of vast caldrons of lava in furious ebullition, sometimes spouting to the height of seventy feet; while the burning flood, rolling onward like a river beneath a fiery arch, plunged down and was lost in a deep abyss.

² The structure of lava depends mainly upon the pressure under which it is cooled; where this is great, a compact mass is formed; but if the lava is subjected to but little pressure, and is inflated with the gas, it is light and porous, forming scoria and pumice-stone. The spray of the lava, driven and cooled by the wind, spins out into fine, delicate threads. These are found in great abundance at Kilauea, and are called by the natives the "hair of Pele," from the name of the fabulous divinity of the volcano.

³ The latter usually occurs; for the rocky walls, thick as they are, are unable to withstand the enormous expansive force of its confined gases and

but more than fifty chemical elements have been discovered in the lavas of Vesuvius.²

When the lava first issues from the crater, it is a viscid fluid; but it quickly cools at the surface, and, being a bad conductor of heat, a firm crust is soon formed, under which the stream of molten rock flows.

4. **Eruptions.**—The phenomena of eruptions are usually quite similar. They are often preceded by subterranean noises and violent earthquakes. Loud explosions follow, during which the floor of the crater is blown out in red hot fragments. Accompanying this are dense clouds of steam and gases, which are shot to a great height.

The eruption of lava follows, and the stream of molten rock either flows over the edge of the crater or bursts through its sides.

The close of the eruption is indicated by the ejection of gases and vast showers of ashes,⁴ which darken the air for days. These not only fall on the adjacent country, but are borne by the winds to regions hundreds of miles distant.⁵ The condensation of the escaping steam is usually followed by showers of corrosive rain, which is more destructive than the lava-flood.

When the volcano rises above the limit of constant frost, the approach of an eruption is shown by the sudden melting of the snow and ice that clothe its summit, giving rise to rapid and destructive torrents.

Other eruptions are marked by an absence of any great display of energy. The crater gradually fills with lava, which



MOUNT ETNA, SICILY.

either overflows its rim or bursts through its sides. The volcano of Kilauea, in Hawaii, is a remarkable instance of this kind. In 1884 this immense crater was filled up with lava to such an

vapors. In nine-tenths of the lava-eruptions of Etna new craters have formed on the sides of the mountain.

⁴ The "ashes" of volcanic eruptions are not the product of burning, but finely pulverized earthy matter.

⁵ Many of these phenomena were strikingly displayed during the eruption of the Soufrière Mountain, on an island of the West Indies. Without warning, the volcano burst forth, showering down sand and dust. Three days afterwards streams of lava belched from the crater and poured down the sides of the mountain in torrents. Red-hot stones and ashes rained down for hours, and, earthquake following earthquake almost incessantly, the whole island undulated like water shaken in a bowl. The next day the atmosphere was clouded with ashes to such an extent that the deck of a vessel five hundred miles from St. Vincent was covered with volcanic dust to the depth of five inches. In other instances volcanic dust has been borne by the wind to a distance of more than one thousand miles.

extent that it broke through the mountain and poured a torrent of lava down its sides.¹

During the three preceding eruptions no violent phenomena occurred: the crater silently filled with lava to the depth of four or five hundred feet before it escaped from its enclosing walls.²

5. Volcanic Force.—The tremendous energy displayed by volcanoes is shown not only by the great height to which masses



COTOPAXI, SOUTH AMERICA.

of rock are thrown, but also by the immense amount of matter ejected. In the eruption of 1872 fragments of rock were hurled from the crater of Vesuvius to a height of two thousand feet or more.³

The amount of matter ejected is enormous. During the eruption of Kilauea in 1823, sufficient matter was ejected to form a conical mountain three thousand feet high, having a base thirty-four hundred feet in diameter. The greatest lava-flood on record is that which, in 1783, burst from Skaptar Jökul in Iceland, and continued to flow for two years. It formed two principal rivers, which flowed in nearly opposite directions, one being fifty and the other forty miles long. The amount of matter thus ejected was sufficient to cover London with a mountain rivalling in size the Peak of Teneriffe.⁴

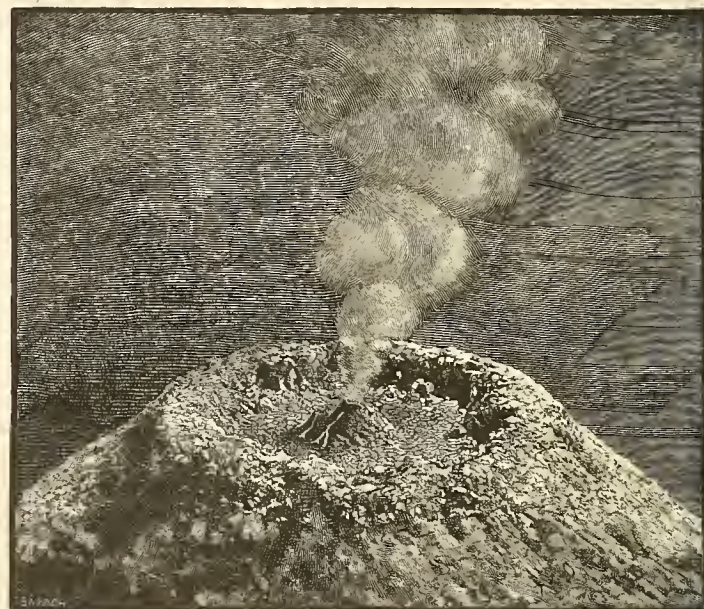
Constantly Active Volcanoes occur in various parts of the world, but their eruptions are not characterized by violent outbursts: they consist merely in the formation of immense

bubbles of steam and other vapors, which rise from the bottom of the lake of lava and burst at the surface. There are neither earthquakes nor showers of ashes and scorice. The level of the lava within the crater varies, sometimes sinking out of sight, and sometimes rising so high that a torrent of molten matter pours over the rim of the crater.

The eruptions of Stromboli, a volcanic island near Italy, are of a similar character. The phenomena are simply those of a viscous mass in a state of boiling.

6. Nature of Volcanoes.—Volcanoes are now regarded as the upper orifices of channels which descend through the crust of the earth to the reservoir of molten matter below. Here the gathering vapors and gases are at times so compressed that they acquire enormous power; and, forcing up vast streams of melted rock, an eruption, with all its terrific phenomena, is the result.⁵

When the force is expended, the volcano once more reposes, to be again disturbed whenever the imprisoned gases and vapors reassert their might. Volcanoes are, therefore, the safety-valves of the globe.



CRATER OF VESUVIUS BEFORE THE ERUPTION OF 1872.

After an eruption, the crater of a volcano presents a desolate appearance. Where the volcanic action is still powerful, the

¹ During an eruption of Mauna Loa, in 1843, the flood spread out and cooled, and a crust was formed on the surface of the flood of lava, beneath which rushed the river of molten rock at the rate of from ten to fifteen miles an hour. The lava-stream extended a distance of sixty-five miles, and was from one to ten miles wide, while its depth ranged from ten to three hundred feet. Neither earthquake nor shower of ashes and cinders attended this eruption.

² In the eruption of 1840 the main stream of the lava burst from the earth at a point twenty-seven miles from the crater, and twelve miles from the sea, towards which it flowed. The width of the stream varied from one to four miles; and when it reached the sea it poured over a precipice fifty feet high, in a fiery cataract half a mile broad.

³ During an eruption of Teneriffe stones were projected to altitudes varying from twenty-six hundred to thirty-six hundred feet. But these instances of projectile forces are far exceeded by the might of the volcano of Cotopaxi, which is said to have hurled a rock three hundred cubic feet in size to the distance of nine miles.

⁴ The beautiful cities of Herculaneum and Pompeii were completely buried by the showers of ashes ejected by Vesuvius in the year 79. During the eruption of Tomboro, one of the Sunda Islands, so much ashes were ejected that houses forty miles distant were crushed beneath them.

⁵ In 1882, the Krakatoa, an island situated in the Strait of Sunda, was the scene of a most destructive eruption. Without a moment's warning, the island was rent by tremendous explosions, which followed one another in quick succession. During the terrific convulsions nearly one-half the island disappeared. Showers of ashes and rocks, together with the corrosive rain which followed, enveloped the western provinces of Java in destruction. During the same year, Bogosloff, a volcanic peak among the Aleutian Islands, was in eruption for nearly a year. Mt. St. Augustine, situated on an island in Cook's Inlet, was also in eruption. The convulsion split the island in twain, and a narrow strait now separates the two parts. In 1886, Tarawera Mountain, situated in the geyser region of New Zealand, was the scene of a violent eruption. The eruption took place near an old crater which formed Lake Rotomahana. After the first outburst the waters of the lake poured into the opening, and a series of terrific explosions occurred, which blew out the bottom of the lake. There remained a few smaller craters, which ejected mud to a great height. Many other old craters were opened, discharging thick mud or else dense sulphureous vapors. The vast amount of mud covered many square miles of the most fertile valleys, filling the beds of the streams so that the latter overflowed their banks, and completed the destruction. The quantity of volcanic sand and ashes which is thrown out during eruptions is almost incredible.

crater is almost entirely filled with smoke and noxious vapors, and the sides and bottom are covered with deposits of sulphur



IZALCO, CENTRAL AMERICA.
(Old crater on the right.)

and other minerals. Such is the Solfatara, near Puzzuoli, in Naples, which the Romans regarded as the entrance to the infernal regions.



THE PACIFIC GIRDLED BY VOLCANOES.

7. Extinct Volcanoes.—Extinct volcanoes are those in which all signs of activity have ceased. They are very numer-

¹ It is possible that an extinct volcano, so called, may in some cases be only one in repose; for, previous to A.D. 63, Vesuvius, which is now active, exhibited the appearance of an extinct volcano.

² The torrid zone abounds in volcanoes. Of all the volcanic regions of the globe, Java is the most remarkable; for, though only about the size of the State of New York, it contains more than fifty volcanoes, of which twenty are active.

³ The fact that so many volcanoes are situated near the sea-coast and on islands, and that eruptions sometimes occur in the depths of the ocean, has

led to the belief that these phenomena are caused by the waters of the sea penetrating to the heated interior of the globe. But the existence of volcanoes far distant from any considerable body of water makes this theory somewhat doubtful.

8. Distribution.—It will be seen from the accompanying map that by far the greater number of volcanoes girdle the vast Pacific Ocean.² This chain, beginning with the Kamchatka series, extends south through the Kooril, Japan, Molucca, Philippine, and Sunda Islands, to New Zealand.

On the eastern side of the Pacific it is prolonged through South America, Central America, Mexico, and the Northwest coast. The circuit is completed through the Aleutian Isles. This immense zone contains more than six-sevenths of all the volcanoes of the world, and five-sixths of all that are active.³

A second chain, situated in the Atlantic Ocean, extends from Jan Mayen Island, through Iceland, the Azores, and adjacent islands, to Tristan d'Acunha. A spur of this chain stretches eastward through the Mediterranean Sea.



MUD-VOLCANOES OF TURBACO, SOUTH AMERICA.

9. Mud-Volcanoes.—The mud-volcanoes of Turbaco consist of about twenty cones, varying in height from nineteen to twenty-five feet, their craters being filled with water and soft clay. More than twice a minute bubbles of gas burst up through the liquid mass with considerable noise, and with sufficient force to cause the water to flow over the rim.⁴

The mud-volcanoes of Aguachapa, in Central America, are known to have been in action for the last three hundred years. A dense white steam rises from a semi-fluid mass of mud and water, which boils furiously, occasionally ejecting a torrent of thin mud. The ground all around is too hot to tread upon. In Central Asia, Sicily, Java, and Trinidad, mud-volcanoes are likewise found.

⁴ The "mud-lumps" of the Mississippi Delta, and the alleged mud-volcanoes near the mouth of the Indus, have no connection with volcanic energy. The former are probably due to underground streams of water, which accumulate until they force a passage through the overlying sediment to the surface, thereby causing an "eruption."

10. Field of Fire.—The district of Baku, situated west of the Caspian Sea, not only abounds with mud-volcanoes, but also contains a large depressed region, termed the *Field of Fire*. The soil is here impregnated with naphtha, and the surface is filled with cracks, which emit various inflammable gases.

CHAPTER VII.

EARTHQUAKES.

1. Earthquakes and volcanoes are very closely connected, since in many instances they arise from the same causes. One may occur, however, without the other, or both may convulse the earth at the same time.

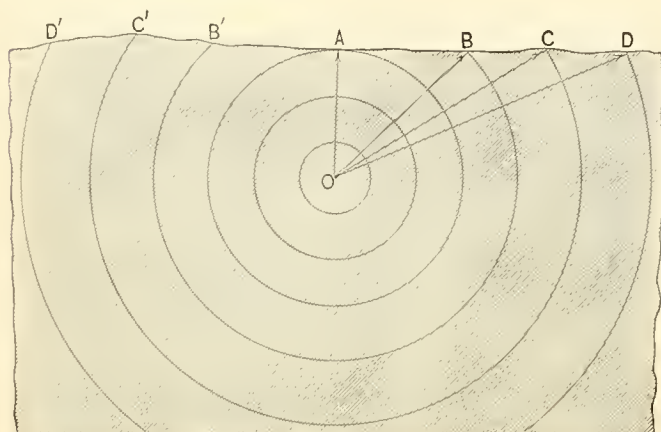


DIAGRAM ILLUSTRATING THE PROPAGATION OF EARTHQUAKE WAVES.

2. Nature of Earthquakes.—The earth-shock, or jar, consists of vibrations or undulations of a part of the earth's crust. Such undulations do not differ materially from the waves that are formed when a stone is dropped upon the smooth surface of a pond. At the spot where the stone drops, the water has an up-and-down motion. Each undulation spreads from the centre, and a series of concentric waves are thus formed.

For instance, a shock or concussion may occur at some point, as O, ten or fifteen miles below the surface of the earth. The shock reaches the surface first at A. Here the undulations are vertical, and are almost explosive in their effect. At a distance of a few miles from A, as B, C, and D, the undulations will partake of both the horizontal and the vertical motion—producing a “rolling” effect that is more destructive even than the vertical waves. At a still greater distance the undulations become gentler, constituting rolling waves, or “tremblors.” Wherever they occur the surface of the earth rises and falls alternately, like the billows of the sea.

Rolling earthquake waves at times acquire a whirling or rotatory motion. This movement, fortunately, is rare. It takes

¹ At Calabria, Sicily, a large rock which, before the earthquake, extended north and south, afterwards ranged east and west. During the earthquake at Valparaiso, Chili, two solid buttresses were so twisted that their faces formed an angle with the wall to which they were formerly parallel.

² At Lisbon, about half-past nine o'clock in the morning, on the 4th of November, 1755, a rumbling subterranean noise, like the rolling of carts, was heard, which gradually increased, and, after a few seconds, resembled the firing of heavy cannon. At this moment a shock was felt, which levelled the Palace of the Inquisition and the cathedrals, which were filled with people. Three other shocks followed within the space of five minutes, prostrating nearly all the remaining large buildings. Many who had escaped the falling walls fled to the sea-shore; but an immense wave

place only in the most violent earthquakes, twisting objects around without overthrowing them.¹

The earthquake at Riobamba, Ecuador, in 1797, furnished a striking example of both vertical and whirling undulations. The city was situated immediately over the centre of disturbance, where the earth-waves were ten or twelve feet in height. Houses were thrown into the air; human bodies were hurled across the river to the top of a hill several hundred feet high, and the streets were twisted out of position to such a degree that their courses could not be traced.

3. Areas of Disturbance.—The areas of disturbance are sometimes circular, but more commonly they are elliptical in form. In extent they vary greatly.

In the Calabrian earthquake of 1783, of which the town of Oppido was the centre, the most intense shocks were confined to an area of five hundred square miles: within this region two hundred towns and villages were destroyed, and 100,000 persons perished. In the great earthquake of Lisbon, in 1755, the vibrations extended over a tract equal in extent to one-twelfth of the whole surface of the globe.

4. Sounds.—Subterranean sounds frequently attend earthquakes. Quite commonly they resemble the rattling of a heavily-loaded wagon driven over a gravelled road—a crunching sound being especially noticeable. Such sounds usually accompany the earthquake, though they sometimes precede it.

Sometimes the shock comes without any warning sound. Such was the case in the frightful earthquakes at Lima and Riobamba. On the contrary, a subterranean noise was heard for a month at Guanajuato, Mexico, without any movement whatever. At the depth of 1600 feet the noise was as loud as at the surface.



AN EARTHQUAKE IN SOUTH AMERICA.

5. Effects of Earthquakes.—The greater number of earthquakes pass away without leaving any marks of their occurrence; but others are terribly destructive. Those of Lisbon in Portugal, and Caraccas in Venezuela, illustrate their energy.²

rolled in upon the shore and swept them away. Still others took refuge upon the marble quay, and, to add to the horror, this structure, with those who were on it, sunk beneath the waters. The sea rose forty feet above high-water mark at the mouth of the Tagus, and rushed upon the devoted city with incredible speed, overflowing the lower streets, and finishing the destruction. By the earthquake and inundation 60,000 persons perished; and to the horrors caused by these were added the ravages of fire. At Oporto, north of Lisbon, the earth-shocks were very severe. At Cadiz, to the south, the sea rose sixty feet above its level, and rolled in a huge wave over the land, demolishing the walls and fortifications of the city on the ocean side. The highest mountains of Portugal were convulsed and rent asunder, and vast masses of rock hurled into the valleys.

The earthquake of Caraccas occurred on the 26th of March, 1812, during a calm and cloudless day. It was Holy Thursday, and most of the population were collected in the churches. The first shock caused the bells of the churches to ring and the earth to undulate like a stormy sea. It lasted about six seconds, and was followed by a loud, subterranean noise.

This was succeeded by a vertical shock, which lasted three or four seconds, closely followed by undulations which crossed one another. In about the space of a minute the city was levelled to the ground, and 10,000 people were buried beneath the ruins of the churches and houses.

6. "Tidal" Waves.—The effect of the earthquake upon the ocean was strikingly displayed at Simoda, Japan, in 1854. Shortly after the shock, five tremendous waves, alternately rolling shoreward and receding, overwhelmed the town, carried the largest junks two miles inland, and wrecked a large man-of-war then lying in the harbor. These waves were propagated across the Pacific Ocean to the coast of California.

After the earthquake at Arica, Chili, in 1868, tidal waves sixty feet high rolled in upon the shore, and several hours elapsed before they entirely subsided. A United States iron-clad vessel was carried high upon the beach by one of these waves.

7. Upheaval and Subsidence.—By the force of earthquakes the elevation of large regions is sometimes permanently changed. During an earthquake that occurred in the district of Cutch, India, in 1819, the land on the coast sunk, and the sea rushed inward over an area of six hundred square miles, forming an extensive lake; while to the north the ground rose to the height of ten feet, throughout a tract of eight hundred square miles.

During an earthquake in Bengal, in 1762, sixty square miles of the Chittagong coast permanently subsided. A large river was swallowed up, one mountain entirely disappeared, and the top only of another remained visible. Chasms were opened in the earth, and towns sunk twenty feet or more. While this coast was sinking, a corresponding rise took place at the island of Cheduba.

Near New Madrid, in Missouri, in 1812, a tract seventy-five miles long and thirty broad was depressed, during an earthquake, to the depth of several feet. Lakes twenty miles long were formed in an hour; and so high did the ground rise that the current of the Mississippi was temporarily reversed.

The earthquake which occurred in Chili in 1822 raised the land from two to three feet along the coast for a distance of one

hundred miles; and in another great earthquake which convulsed these shores, in 1835, the island of Santa Maria was elevated from eight to ten feet.

8. Occurrence.—According to the observations of Mallet and Perrey, more than six hundred earthquakes occur every year. There are undoubtedly many severe shocks which are not recorded because they occur in localities distant from civilization.

Statistics show also that more earth-shocks occur from October to the following May than during the remaining months of the year. They are also slightly more frequent at the time of full moon than at the change of the moon.¹

Earthquakes are most frequent in volcanic regions, and along the more recently formed mountain-ranges. The severest shocks noted have occurred along the Andes Mountains, in the vicinity of the Mediterranean Sea, and in the Sunda Islands.

Within the United States² shocks are most frequent in the Pacific highlands, where there is an average of about eighteen shocks each year. Along the Appalachian Mountains earthquakes are less frequent. In the basin of the Mississippi River they are of rare occurrence.

The earthquake which shook the Southern and Middle Atlantic States in August, 1886, was the severest ever known within the United States. The focus or centre of this earthquake was a large elliptical area near the coast, directly beneath Charleston, S.C. Many of the larger buildings in that city were overthrown, and nearly all were greatly damaged.

9. Causes.—In volcanic regions, earthquakes are attributed to the sudden formation of gases, which, under tremendous pressure, rend or otherwise disturb the overlying strata of rock.

In other localities it is probable that the shock is the result of "faults," or breaking of the strata of sedimentary rocks.

The "line of weakness," which extends along the Appalachian Mountains from New York to Georgia, is marked by a multitude of such "faults" or displacements in the strata whose folds constitute this mountain system. It is probable that each "fault" is the record of an earth-shock.

In general, earthquakes are attributed to the gradual contraction of the earth's crust, which is constantly taking place by reason of its cooling. The contraction of the interior is considerably greater than that of the outer crust. If the latter yields gradually there will be no disturbance; but if it resists until the strain is great enough to break the strata, an earthquake results.

on the island of Ischia, was also attended by a great loss of life. In India, Spain, Persia, Italy, Greece, and on the northern coast of Africa prolonged shocks were not only very frequent, but also unusually severe. During this period earth-shocks were frequent along the western slope of the Andes. In 1883 about forty sharp shocks and a great number of lighter ones were recorded at Valparaiso. In the month of November light shocks occurred there nearly every day.

In 1885 sixty-six earth-shocks were recorded in North America, distributed as follows:

Atlantic Slope (including West Indies).....	24
Great Central Plain.....	3
Pacific Highlands (including Mexico and Central America).....	39

Arranged according to the time of their occurrence, they accord with the law noted in paragraph 8:

January.....	8	July.....	5
February.....	7	August.....	4
March.....	7	September.....	2
April.....	11	October.....	7
May.....	3	November.....	2
June.....	3	December.....	7

Forty-two shocks, it will be seen, occurred from November to April, inclusive, and twenty-four during the remainder of the year. The geographical distribution shows that they are severest and most frequent in and near mountain-folds.

¹ It is inferred from this that the greater attraction of the sun and moon at such times increases the strain upon the earth's crust.

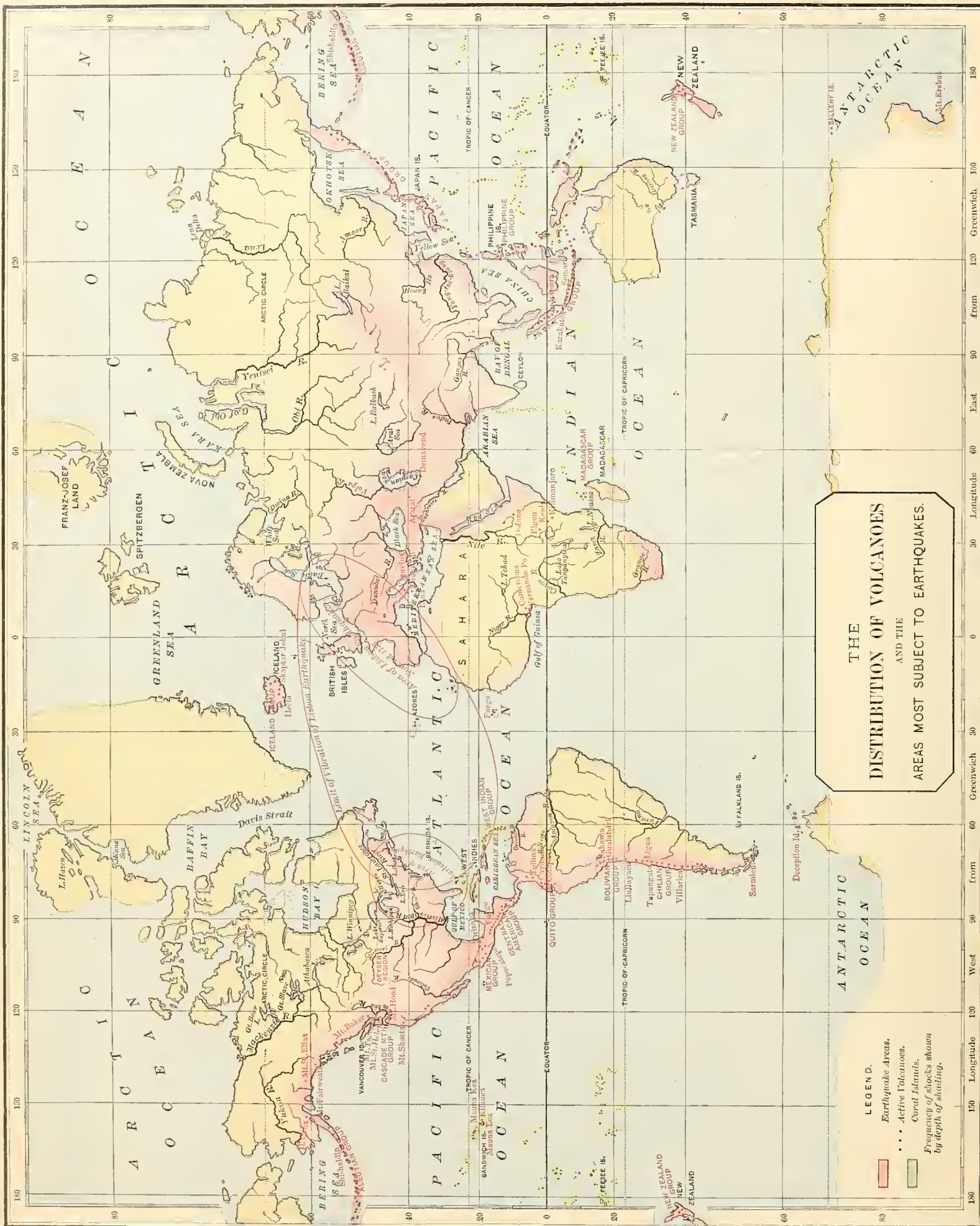
² A severe shock occurred in August, 1884. The focus or centre of the shock was directly beneath New York City, where the undulations were vertical. This shock was felt as far north as Concord, N.H., and as far south as Washington, D.C. Although strong, it was not destructive.

During a period of twelve years, ending with 1883, three hundred and sixty-four earthquakes were recorded in the United States and Canada. Geographically, these were distributed as follows:

Atlantic Slope.....	147
Mississippi Valley.....	66
Pacific Slope.....	151

It appears, therefore, that in this area there is an average of about two shocks each month. This is at the rate of about one each month for the coast regions, and one for every two months in the Mississippi Valley. In the sparsely-settled regions of the Pacific highlands undoubtedly many light shocks escaped notice.

The six years ending with 1886 were remarkable for the great number of terrestrial convulsions. During this period many volcanic eruptions occurred, and several new volcanoes sprung into existence. Earthquakes of extraordinary violence disturbed large areas. The shock accompanying the outburst of Krakatoa was the most destructive of any occurring during the present century. The earthquake which destroyed Casamicciola, a city



REVIEW AND MAP QUESTIONS ON VOLCANOES AND EARTHQUAKES.

VOLCANOES.

What is a volcano?
Describe its structure.
Describe the crater of a volcano.
What is said of the composition and structure of lava?
Describe the phenomena of a violent eruption.
What are the "ashes" of an eruption?
What is said of the eruptions of Kilauea?
In what way is the energy of volcanic force shown?
What is said of the lava-flood during the eruption of Skaptar Jökul?
What is the character of the eruptions of constantly active volcanoes?
To what are the eruptions of Stromboli compared?
What are extinct volcanoes?
Describe the eruption of Krakatoa.
What other eruptions occurred during the same year?
Describe the eruption of Tarawera, New Zealand.
To what are volcanic eruptions sometimes attributed?
What is said of the number and distribution of volcanoes?
Name some of the active volcanoes on the northwest coast of North America
(see map, page 38).
Describe the volcanic chains of the Western Continent.
Where are the principal volcanoes of the Western Continent?
In what part of the continent is the principal chain found?
What ocean does it skirt?
Name some of the principal volcanoes in the West India Islands.
Name some of those of Central America and Mexico.
Mention the principal active volcanoes of South America.
What are the principal volcanic chains of the Eastern Continent?
In what country are volcanoes numerous for its size?
Mention some of the active volcanoes of the Eastern Continent.
What chain extends between America and Asia?
What chain extends through the Mediterranean Sea?
What ocean is almost wholly girdled by volcanoes?
In what zone are they most numerous?
In what island is volcanic activity most remarkable?
Are volcanoes most numerous in the interior of continents, or near the
ocean?
What central groups are found in the Pacific Ocean? The Atlantic
Ocean? What volcanoes occur in the Indian Ocean?
What extinct volcano is in the Azores?
What is said of mud-volcanoes?
Mention the localities in which they occur.

What is said concerning the "mud-lumps" at the mouth of the Mississippi
River?

What is said concerning the Field of Fire?

EARTHQUAKES.

What is said of the relation between volcanoes and earthquakes?
Explain the cause of earthquake shocks.
Draw a diagram like that on page 36, and show the localities at which the
waves will be vertical.
What are rolling waves? What is their effect?
How was this shown during the earthquake at Riobamba?
What was their effect at Calabria?
What is meant by the area of disturbance?
What is said of its shape? Of its size?
What is said of the sounds that frequently attend earthquake shocks?
What is said concerning the destructive effects of earthquakes?
Where are the earthquake regions of the Western Continent?
Near what ocean are they chiefly situated?
In which of these regions are earthquakes most frequent?
Mention the earthquake regions of the Eastern Continent.
In which of these are earthquakes most frequent and severe?
What is the "tidal wave"?
What is said of the tidal wave at Simoda? At Arica?
Mention some of the permanent effects of earthquakes.
What is said of the effects of the earthquake in Cutch, India?
What were the effects of those at New Madrid, Missouri?
Describe the earthquake of Lisbon.
Give the probable limits of its undulations.
Bound the earthquake districts of the Mediterranean Sea and Central Asia
(see map, page 38).
Describe the Red Sea district.
Give an account of the limits of the earthquakes of India and Central Asia,
as shown on the map.
What is said concerning the occurrence of earthquakes?
In what localities are they most frequent?
During what months of the year do they occur with greatest frequency?
What is said of earthquakes in the United States during the twelve years
ending with 1883?
How many took place in the Pacific highlands? On the Atlantic Slope?
In the Great Central Plain?
What is said of the earthquake at Charleston, S.C.?

CHAPTER VIII.

CAVERNS AND NATURAL ARCHES.

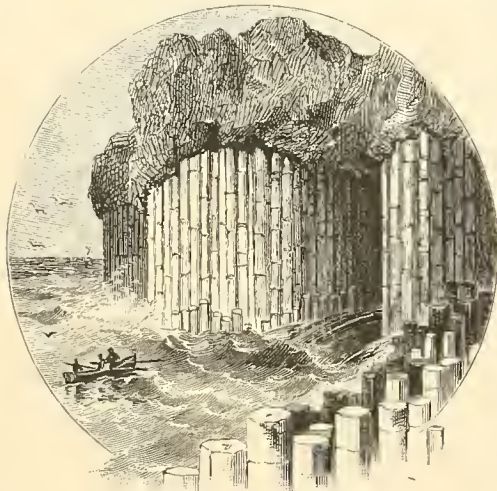
1. **Caverns.**—Caverns occur chiefly in limestone, but are likewise found in sandstone and in volcanic rocks. Some are narrow fissures, piercing deeply into the earth; others are tunnelled caves, and still others consist of a series of cavities or chambers connected with one another by passages of varying shape and extent.

The Mountain of Torghåttén, in Norway, is pierced by an opening 150 feet high and 3000 feet long; and twice in the year the sun's rays pass through this shaft from one extremity to the other. A great number of such tunnels are found on the coast of the island of Heligoland and also upon the shores of New Zealand.

In the Bonin Islands, in the Sea of Japan, similar formations exist. Within the harbor of Port Loyd a natural tunnel passes through basaltic rock from the Southern Head to the beach on the other side. The entrance is about fifteen feet wide and thirty feet high; but the roof within soon rises to the altitude of forty or fifty feet, and has almost precisely the appearance of an artificial arch.

2. **Volcanic Caves.**—Fingal's Cave, in the isle of Staffa, is the finest known example of a cavern formed by volcanic rocks.

The isle of Staffa consists of pillars of basalt, its name, signifying a *staff* or *column*, being derived from its peculiar structure. The basaltic columns that constitute the island have been broken away by the power of the waves, and various caves have thus been made, the grandest of which is the cave of Fingal.



FINGAL'S CAVE, STAFFA.

This cavern is nearly 400 feet long and more than 100 feet high. The floor is composed of lava, with ranges of regular basaltic columns resting upon it and supporting the massive rock-work that forms the ceiling.

In the torrent of lava that flowed from the Bald Yökul, in Iceland, a vast cavern occurs, forty feet high, fifty feet broad, and nearly a mile long. Masses of beautiful black lava, shaped like icicles, hang from the roof; the sides are variegated with vitrified horizontal bands, and the floor is covered with solid ice, clear as crystal.

3. **Limestone Caves.**—Limestone caverns are distinguished from others by mineral incrustations, termed *stalactites* and *stalag-*

mites, formed by water, impregnated with lime, that trickles through the roof.

Part of the water evaporates upon the roof, leaving the lime, which, in process of time, forms a hanging mass like an icicle: this is the *stalactite*. The water which falls upon the floor also evaporates, and the lime deposited rises from the floor in a



DEAD SEA, MAMMOTH CAVE.

pyramidal column, forming the *stalagmite*. Not unfrequently the ascending stalagmite and the descending stalactite meet and blend, forming arches and grottos and curtains of translucent stone.

The Cave of Adelsberg, near Trieste, in Austria, is a limestone cave, which consists of various halls and grottos, adorned by an immense number of translucent pillars. The sides of many of the grottos are draped with brilliant incrustations, so thin and transparent that they appear like curtains of the purest crystal.

Abysses 500 and 600 feet deep are found within this cavern; and in its recesses a river winds its course, spanned by bridges formed of stalagmites. One of the bridges is from 500 to 600 feet above the stream.¹

Wier's Cave, in Rockingham County, Virginia, though not very extensive, is one of exceeding beauty. Its length in a direct line is 1600 feet; but, with all its windings, it measures about 3000 feet. Here halls and galleries succeed one another, adorned with dazzling incrustations wrought into the most singular forms.

The Mammoth Cave of Kentucky is the most remarkable curiosity of this kind, and one of the largest yet discovered. It contains two hundred and twenty-six avenues and galleries, forty-seven chambers, several lakes, and three rivers, one of which is deep enough to float a ship.

An immense vault, called the Temple, comprises an area of two acres, crowned by a dome of solid rock one hundred and twenty feet high. The Mammoth Dome, four hundred feet in height, overarches a hall of great beauty and magnificence. The Dead Sea is a lake of considerable extent, within which are found the so-called eyeless fish.²

¹ Within this cavern lives the Protens—a singular animal, white and transparent, with a shape between that of the lizard and that of the eel.

² The eyes of this species (*Pisces Bartineii*) are not absent, but remain in a rudimentary condition. The fish is thought to be destitute of sight.

4. **Zoolitic or Bone Caverns.**—Many caverns possess a high interest from the fact that they are the depositories of the remains of extinct species of animals, and thus afford much information respecting the geological changes of the globe. Such caves have received the name of *zoolitic* or bone caverns.

5. **Natural Arches.**—The Natural Bridge of Virginia is one of the most celebrated natural arches in the world. A magnificent arch, of ninety feet span and eighty feet wide, unites the opposite banks of Cedar Creek at the height of two hundred and twenty feet above the water. The arch is covered with soil sufficiently deep to support a thick growth of arbor vite. These trees, with the masses of rock that form parapets on either side, so effectually conceal the ravine from the traveller that he might cross the arch unconscious of the wonder beneath him.

Near Bogota, in Colombia, are the natural bridges of Icononza, consisting of masses of rock lying across a chasm of great depth.



NATURAL BRIDGES OF ICONONZA, UNITED STATES OF COLOMBIA.

The higher arch spans the abyss at the height of three hundred and eighteen feet above the torrent. Sixty-four feet below this bridge is a second, composed of three immense rocks, which have so fallen that they are wedged together and form a second arch.

CHAPTER IX.

MINERAL PRODUCTIONS.

1. **The Mineral Products** of the globe may be arranged for the most part under the following classes:—*Building Materials, Precious Stones, Useful Metals, and Ores.*

¹ Pompey's Pillar and the famous obelisks at Alexandria, called Cleopatra's Needles, are constructed of the red Egyptian granite. The first of

BUILDING MATERIALS.

2. **Granite** possesses great strength and hardness, and is admirably suited for vast and enduring structures. Syenite and gneiss are varieties of this rock, and are much admired for their beauty.¹

Granite constitutes some of the loftiest mountain-chains of the Eastern Continent, and is abundantly distributed over the northeastern part of America. Fine varieties are found in the Rocky Mountains and in various localities along the Pacific coast.

Sandstone consists of grains of sand cemented together, either by lime or by oxide of iron. The former includes the white and gray varieties; the latter, the famous brownstones.

Sandstone is widely diffused throughout the globe, and is abundant in various parts of the United States. Extensive quarries of the finest quality occur at Portland, Connecticut, which furnish large supplies for the Atlantic States.

Limestones include the different varieties of marble, oolitic, or bird's-eye limestone, and chalk.

These formations are very extensively distributed, and are largely employed for building purposes. Paris is built of marble; some of the pyramids of Egypt are constructed of limestone; and the buildings of ancient Rome were made of *travertine*, a calcareous deposit found along the base of the Apennines.

Throughout the Mississippi Valley varieties of limestone are extensively employed as building materials.

Marble is widely distributed, and has, from remote ages, furnished the architect and sculptor with materials of great value. Southern Europe is noted for the fineness and variety of its marbles. The best are those of Pentelieus and of Paros. Black or Portoro marble is found in Italy.

Many of the varieties of marble in the United States are of rare beauty, especially those of Tennessee and California. The fine grain and snowy whiteness of the Vermont marble have made it of great value to the sculptor. Calcareous rocks furnish lime, the indispensable material for mortar and cement.

Slate, such as is used for roofing, is generally found imbedded in slate rocks of a coarser kind. The finest slate quarries are those of Penrhyn, in North Wales. Quarries of excellent slate are found in Pennsylvania, Vermont, and California.

PRECIOUS STONES.

3. **Diamonds** are found usually in gravelly banks and in the beds of rivers. In the Eastern Continent, the celebrated mines of Golconda, in India, are famous for these gems. They are abundant in Borneo, where the largest in the world have been found. In the Western Continent, Brazil is famous for these costly gems, and furnishes most of the diamonds of commerce. By far the greatest number are now obtained in the Kimberly mines of South Africa.

Rubies and Sapphires are found chiefly in Ceylon, in the beds of streams. The gravel of the river beds in Birmah contains the *Oriental star* and *opalescent* rubies. The *spinel* ruby is

these structures, although it is eighty-eight feet high, and nine feet in diameter at the base, is formed of only three pieces.

found near the city of Ava: it also occurs in Brazil and the United States. Birmah is likewise rich in sapphires.

Emeralds of rare beauty occur in Colombia, South America, in Upper Egypt, and in the valley of Tunea at Santa Fé.

Opals of the finest quality come from Mexico, Hungary, and Australia. Those which are most prized are opaque, of a pale, milky, iridescent tint.

Garnets are found in Ceylon, in the Hartz Mountains, and in many other localities; but the most beautiful occur in Bohemia and Hungary. They are very abundant in the United States.

The inferior gems, such as agate, chalcedony, topaz, carnelian, beryl, and amethyst, are very widely distributed. Topaz, beryl, and amethyst are abundantly found in Brazil and Siberia. Agates of rare beauty exist in profusion on the shores of Lake Superior and the table-lands of Oregon.

METALS.

4. The metallic products of the globe are of the utmost importance to man, inasmuch as they are closely connected with the civilization of the human race.

Metals are very abundantly diffused throughout the world; and there are few regions of any extent which do not possess some of them.

A few metals are found in a pure state; but in general they exist in the form of ores, in which the metal is chemically combined with other substances. The ores are usually deposited in veins, or fissures of the rocks; but a few metals, such as gold, tin, and copper, are disseminated through the rocks themselves.

Gold is found in almost every country, but always in minute quantities. It occurs, for the most part, in a native or metallic state, disseminated through quartz rock. It is found also in the form of scales and grains in gravel-beds and river-bottoms.

In Europe, the mines of Austro-Hungary and the bed of the Danube yield a large annual product. It is found also in Spain, and in the Ural Mountains. Gold abounds in the Altai Mountains, in Farther India, and in the islands of Japan and Borneo.

Africa has for a long period yielded rich supplies of gold. The most celebrated of its auriferous regions are the mines of the Guinea coast. Most of the streams from the highlands of Africa bring down gold.¹

The gold-regions of Australia are situated in the southern portion of the island, along the base of the Blue Mountains, the richest mines occurring in the provinces of New South Wales and Victoria. These deposits were discovered in 1851.

In the Western Hemisphere gold is found in immense quantities. The western slopes of the Andes abound with this metal, and it is found also in the gravel of the table-lands. Rich gold-fields occur also in Brazil.

In the United States it is found in a belt of land stretching from Georgia to Nova Scotia. But all other gold districts are surpassed in richness by the auriferous belt which includes the gold-fields of California, Colorado, Idaho, and Nevada. This

¹ In 1858 the Welcome Nugget was found at Ballarat. It weighed 2020 ounces, and was worth \$35,000. The product of the Australian gold-fields, up to 1880, has been \$1,260,000,000.

² One of the richest regions is that of Copiapo, in Chili, where silver was first discovered in 1832 by a native, who, upon casually pulling up a

gold-belt, since its discovery in 1848, has produced nearly as much as all the remaining mines in the world together. The mines of California alone have yielded nearly \$1,600,000,000.

Silver occurs in many localities throughout the Eastern Continent. Among the richest silver-mines are those of Hungary and Sweden, and the Ural Mountains.

The Western Hemisphere far exceeds the Eastern in its yield of silver.² It there occurs abundantly in the western highlands. In the United States the silver deposits are richest in the Great Basin. The famous Comstock Lode of Nevada has produced more silver than any other mine in the world. There are also extremely rich mines in Mexico.

In South America, silver occurs along the whole range of the Andes. Among the most productive mines are those of Pasco, which have been worked from the beginning of the seventeenth century. The mines of Potosi and Chollar are also celebrated for their enormous yield.

Silver is generally combined with lead, and a large quantity is extracted from the latter metal.

Platinum, a rare but extremely useful metal, occurs chiefly in Brazil and on the European side of the Ural Mountains. Limited quantities are found in California and Oregon. Platinum usually exists in connection with such metals as gold, palladium, and iridium.

Iron, the most useful of all the metals, is diffused throughout the world in immense quantities. This metal is very abundant in Siberia and the Altai and Ural Mountains. Sweden, Norway, Russia, Germany, Belgium, France, and England are all rich in iron. Whole mountains of iron occur in Lapland. This metal is likewise profusely distributed throughout Eastern Asia.



PILOT KNOB.

Immense quantities of iron exist also in the United States. Iron Mountain and Pilot Knob, in Missouri, are among the richest deposits of iron in the world, and are exceedingly productive. It is found in the Rocky Mountains, and is very abundant in Michigan, Pennsylvania, and New York.

shrub, found a large mass of pure silver beneath the roots. Within four days after the discovery sixteen veins were found, and lumps of pure metal were gathered from the surface of the soil: a single mass was obtained which weighed 5000 pounds. These mines extend over an area of one hundred and fifty square leagues.

Copper, like iron, is widely distributed. Nearly every country in Europe produces it, Africa yields it, and it is found abundantly throughout Asia. Siberia is extremely rich in copper, where it exists both in a pure state and in the form of *malachite*, or carbonate of copper. Copper-mines of great value exist in Cornwall, in England.

But by far the richest of all the copper deposits hitherto discovered occurs in a region south of Lake Superior. Vast quantities of copper exist here in a pure state, and in masses of enormous weight. Copper is also abundant in Arizona and New Mexico.

Tin is produced in comparatively few places. The rich tin-mines of Cornwall, in England, have been worked from very remote times; for it is certain that the Phœnicians resorted to Britain for their supplies of tin. Saxony is rich in tin, and it occurs in Bohemia, France, and Spain.

The best quality of tin comes from the isle of Banca, near the peninsula of Malacca; and an exceedingly rich deposit occurs at Tenasserim, in the Malay Peninsula. Extensive beds of tin occur in Siberia near the Desert of Gobi. It is also found in Chili, Mexico, and California.

Lead abounds in England, Spain, Saxony, and Bohemia. Large deposits occur in the western highlands of North America, and in Illinois, Iowa, and Wisconsin.

Mercury is found in but few regions. It occurs in Idria in Austria, and in the rich mines of Almaden in Spain, which were worked seven hundred years before the Christian era. The richest mines in the world are those of New Almaden, California.

In 1882 the total production of the quicksilver-mines of the world was 5202 tons, of which more than one-half came from the California mines.

Zinc abounds in England, Scotland, Silesia, Poland, Saxony, and other European countries. Rich zinc-ores are found in New Jersey, Tennessee, Missouri, and in other parts of the United States.

Nickel exists in China, Japan, and the highlands of Europe. It occurs also in the United States. The famous Gap mine of Pennsylvania furnishes the chief supply.

Nickel possesses all the qualities of a most useful metal. It is as bright as silver, as hard as iron, and does not readily tarnish.

Antimony, which is useful not only in hardening alloys, but also in medicine, occurs in the mountainous part of Europe and the western highlands of the United States.

Bismuth is employed chiefly in the manufacture of fusible alloys. Its principal localities are Saxony, Bohemia, Transylvania, Norway, and the western highlands of the United States.

Manganese is widely distributed through the primary and secondary rocks in the state of black oxide. It is found in Great Britain, the Hartz Mountains, and Norway. It occurs in several localities in the United States.

Arsenic is of almost universal occurrence in combination

with other metals. It is used in medicine, and is extensively employed in the arts. It is common in the Pacific highlands of North America.

COAL, ROCK-SALT, AND SULPHUR.

Coal, one of the most useful of the minerals,¹ is distributed throughout the world in great abundance.

It is estimated that the coal-fields of Great Britain cover an area of 12,000 square miles, those of the rest of Europe 10,000 square miles, while 8000 square miles is the extent of the coal-regions of Nova Scotia and New Brunswick.

But these immense deposits are greatly surpassed by the coal-fields of the United States, which embrace an area of more than 150,000 square miles.

The chief kinds of coal are *anthracite* and *bituminous*,² under which divisions there are many varieties. The former occurs chiefly in the Appalachian Mountains; the latter in the basins of the Ohio and Mississippi Rivers.

Rock-Salt is found in the rocks of nearly every geological period. Deposits of this mineral most frequently occur in the lagoons that border former sea-beaches.

Immense quantities of rock-salt are found at Wieliczka, Austro-Hungary. The mines are worked in lanes or galleries, which



BEDS OF ROCK-SALT AT CARDONA.

have been extended so far that their united distances are fully eight miles.³

Extensive quarries are found in various parts of the United States. Those of New York, West Virginia, and Louisiana are noteworthy. Carmen Island, off the coast of Lower California, is a solid mass of salt.

Sulphur is obtained from the volcanic districts of both continents. Large supplies are procured from the semi-extinct volcanoes, or solfataras, where this mineral is thickly deposited. It exists also in vast masses, such as Sulphur Island in the Liu Kiu Archipelago. White Island, near Australia, is a mountain of sulphur, eight hundred feet high.

on the contrary, contains a large percentage of hydro-carbons, of which paraffine, naphtha, and common illuminating gas are the most important. Anthracite is best known as *stone coal*; bituminous, as *soft coal*.

³ In one of these galleries a chapel, thirty feet long, twenty-four feet wide, and eighteen feet high, with all its columns, altars, and statues, is cut out of the solid salt. In the valley of Cardona, in the Pyrenees, two immense beds of salt, of unknown depth and of great purity, occur in a cliff four or five hundred feet high. In Afghanistan a road is cut out of rock-salt, at the foot of precipices one hundred feet in height, formed of this mineral.

¹ Although classed among minerals, coal is of vegetable origin. It consists mainly of vegetable matter that accumulated during former ages, and which, at subsequent periods, were covered with the sediment swept over them by the sea. The great pressure of the overlying sediment, together with the heat arising from the decay of the vegetable matter, partly charred the woody tissue, and pressed it into the form in which coal strata are now found.

² Coal is not pure carbon. In most cases it is a mixture of carbon with various compounds of hydrogen and carbon, called *hydro-carbons*. Anthracite coal consists almost wholly of uncombined carbon. Bituminous coal,



SAGUENAY RIVER.

ICEBERGS.

LAKE ITASCA.

PART FOUR.

WATER.

1. **Water**, the liquid portion of the globe, constitutes its second grand division. It consists of hydrogen and oxygen, chemically combined in the ratio of one part of the former to eight of the latter. It dissolves so many substances with which it comes in contact, that in its natural state it is never pure.¹

The waters of the earth may be considered in their relation to the *Land*, the *Ocean*, and the *Atmosphere*. Each system is governed by its own laws; but all combine to form a wonderful mechanism by which the waters move in a ceaseless circuit.

By evaporation, the sun raises a vast quantity of water from the ocean. This is stored in the atmosphere in the form of invisible vapor, which, borne by the winds, descends upon the land as rain and snow. Thence, gathering in channels of its own making, it returns to the sea.

CHAPTER I.

SPRINGS.

2. **Springs** are those waters which burst spontaneously from the earth.

Of the whole amount of water that descends from the clouds,

¹ Pure water can be obtained only by distillation. It is tasteless and inodorous.

² A dropping spring in Chinese Tartary is described as follows: "Returning towards the plain by another route, we visited the Tamchi-Boulac, or the Dropping Stone;—and a magnificent one it is! It lies at the foot of the Ala Tagh Mountains. The water comes trickling out of the rocks in thousands of little streams that shine like showers of diamonds; while the rocks, which are greatly varied in color, from a bright yellow to a deep red, give to some parts the appearance of innumerable drops of liquid fire. The water drops into a large basin, and runs over fallen masses of stone in a considerable stream."

³ Springs of this kind ascend from an immense depth, and often afford a large and unfailing supply of water. The celebrated well of Grenelle, in

in the form of rain, hail, and snow, a part is evaporated, or else flows into the streams, that bear it again to the ocean. The rest is absorbed by the soil, sinking through porous beds of earth or rocky fissures till it meets with strata of clay or other rock through which it cannot pass.

Here the water accumulates in reservoirs, and at length breaks through the soil as a spring. The permanence and nature of the fountain will depend upon the supply of water and the nature of the soil through which it passes.

The subterranean waters, as they emerge into light, do not always gush forth in a single stream, but often percolate through hills and cliffs, trickling down their sides in drops.²

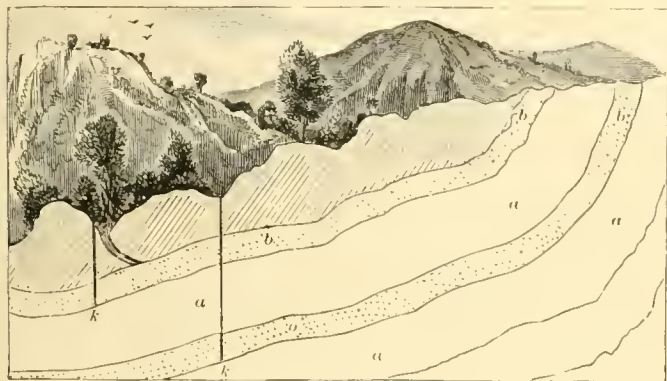
3. **Constant Springs**.—Springs of this kind flow continually, and suffer little or no diminution in their volume during the longest droughts. It is supposed that their reservoirs are so large that the continual flow of water does not drain them during even the driest seasons. Of this character is the famous spring of St. Winifred, at Holywell, England, which discharges 5000 gallons of water a minute. It has never been known to fail, though its volume is affected by drought.

4. **Artesian Wells**.—The subterranean bodies of water not infrequently rest upon *inclined* beds of rock, or impervious strata, with similar strata overlying them.³ In this case, if the reservoir be tapped, the water will rise through the opening to seek its level; and, if the surface of the reservoir be higher than the mouth of the orifice, the water will flow out in a continuous

Paris, was commenced in 1834. In 1839 the boring had reached the depth of 1600 feet without striking water; but when the depth of 1800 feet was attained, a stream ten inches in diameter rushed forth, which discharges 500,000 gallons every twenty-four hours. At St. Louis, Missouri, is an artesian well 3147 feet deep. In 1856 a well of this kind was commenced in the Sahara, in the province of Constantina, under the direction of the French engineers. In the following month water was reached, which gushed forth in a copious stream at the rate of 1000 gallons a minute. The joy of the natives was indescribable. The news of this miraculous flow of water spread rapidly through the country; and the Arabs flocked from afar to see this wondrous spring, to which their religious teachers gave the name of the "Fountain of Peace." Recently additional wells have been sunk along the caravan-routes of the Sahara.

stream, forming an artificial spring. Such springs are commonly called artesian wells.

The following cut explains the principle of artesian wells: *aa* are porous strata through which water descends, and *bb* strata of clay enclosing the former, except at the top. Orifices having been bored through the overlying strata of clay at *kk*, the water which has accumulated in *aa* will rise through the openings and form artificial fountains.



ARTESIAN WELL.

Many thousand artesian wells have been sunk in various parts of the United States, especially in localities where the rainfall is insufficient to insure a full growth of crops.

In California alone, several thousand square miles of land have been made productive that otherwise would have been of little value.¹

5. Periodical Springs.—Spring of this class swell and subside at periods more or less regular. Some flow at short intervals during the day, while in others changes are longer and more variable. Periodical springs are not common.²

The origin of periodical springs is uncertain. It is usually explained as follows: In the accompanying figure, *DKEFG* is the reservoir; *A*, *B*, and *C*, fissures in the rocks through which water flows into the reservoir; *GLO* is a curved channel extending from the reservoir to the surface of the ground. When water has flowed into the reservoir till it is filled to the line *LK*, up to the top of the curved channel, the latter acts as a siphon, and a stream of water issues at *O*. This stream will flow until the water sinks to *G*, when it will cease. It will not be renewed till the reservoir is again filled.

6. Thermal Springs.—Ordinary springs, which have their origin below the limit of frost, possess a temperature almost identical with the mean annual temperature of the region where they are found. Others follow no such law, but range from the mean temperature up to the boiling-point. Some of these derive their heat from volcanic rocks; others, from chemical action.

Near Little Rock, in Arkansas, is a group of eighty hot

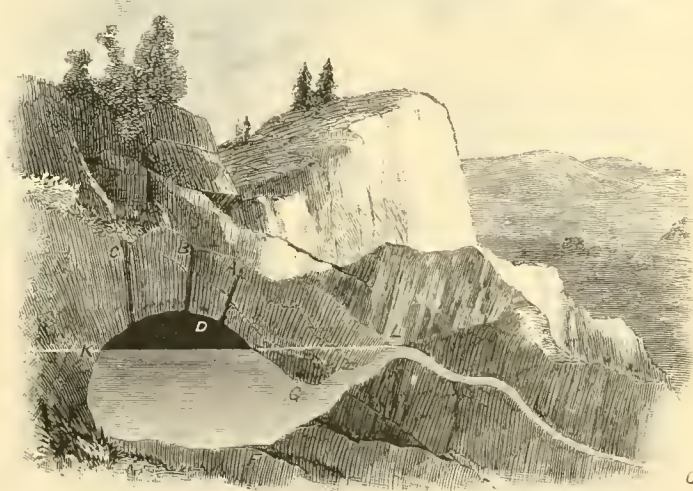
springs, which burst from the side and base of a mountain. The temperature of the water is 150°. Within ten feet of one of these hot springs is a cold spring having a temperature of 50°. The proximity of hot to cold springs is not uncommon. Instances occur in various parts of the United States, especially in the Yellowstone National Park.

Magnificent hot springs are found in New Zealand. Lake Rotomahana, situated in the Auckland Lake district, is heated to 104° by the numerous thermal springs that rise from its bottom and along its banks. One of these springs forms a basin eighty feet long and sixty feet broad, filled to the brim with clear, boiling water, from the centre of which a massive column of water spouts several feet above the surface of the basin.

7. Geysers.—Geysers are hot springs from which, at tolerably regular intervals, jets of hot water and steam are ejected with explosive violence.

The most extensive geyser region in the world is that of the Yellowstone National Park, situated in Northwestern Wyoming. Along the basin of the Firehole River are about 10,000 geysers, hot-springs, fumaroles, and mud-volcanoes.³

“Grand Geyser” throws a column of water to a height of 200 feet, while jets of steam are projected more than 1000 feet. “The Giantess” ejects a column of water 250 feet high. The eruption occurs every eleven hours, and lasts twenty minutes.



AN INTERMITTENT SPRING

“Old Faithful,” which has received its name from the regularity of its eruptions, throws a column of water to a height of 150 feet. Its eruptions occur every hour. It plays each time a quarter of an hour.

¹ There are also large areas in Pennsylvania, Virginia, and Texas which are largely dependent upon artesian wells. In many instances the water rises to the surface and overflows, but usually it does not quite reach the surface.

² One of the most remarkable is the *Nebâ el Fûâr*, near the convent of Mar Jirius, Palestine. At stated intervals it throws out an immense volume of water, sufficient to entitle it to be called a river. At the present time it is quiet for two days and active during a part of the third. This fountain is thought to be the famous *Sabbatic* river, which, according to Josephus, rested during six days of the week and flowed on the seventh. The difference in the present and former periods of ebb and flow may be attributed to the changes to which the spring has been subjected during the

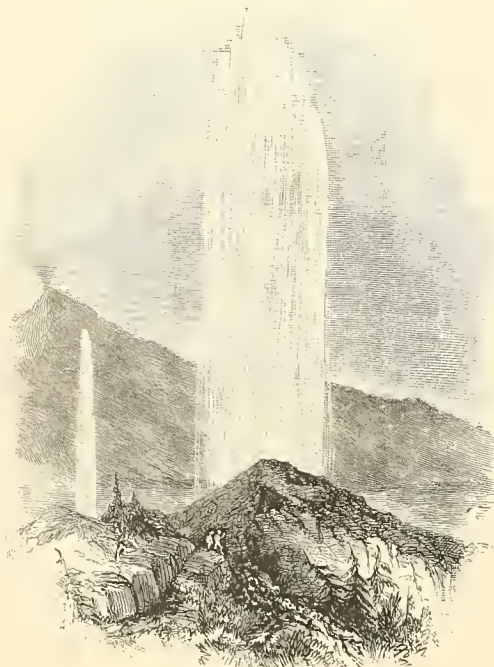
lapse of 1800 years. Near Rogersville, in Tennessee, is a periodical spring, which begins by throwing out at once a large volume of water, forming a brook ten feet wide and four or five inches deep. The stream is quickly expended, and its bed left bare for nearly half an hour, when the flow again suddenly begins.

³ All springs whose waters contain silica (of which sand is an example) are geysers. “In some places the silica is deposited in large quantities, three or four inches deep, in a gelatinous condition, like starch-paste. Trunks and branches of trees immersed in these waters are speedily petrified.” (LE CONTE.) It is probable, therefore, that the geyser builds its own tube from the silica deposited by its waters.

Another group of geysers, in Iceland, has been famous for many years. They occur in various parts of the island, but are most numerous in a plain thirty-six miles from Mount Hecla. Here, within a circuit of two miles, are more than one hundred springs. Many of these boil incessantly without any flowing; others stream upward in lofty jets. The most remarkable of these fountains is the "Great Geyser."¹

The principal eruptions take place after intervals of about a day. They are announced by loud explosions like the discharge

of cannon. Soon the water of the basin becomes greatly agitated, and boils furiously, when suddenly it is projected into the air in a succession of jets, increasing in volume and height, until at last it rushes upwards in a torrent, forming a lofty column enveloped in rolling clouds of steam. The height of the jets varies with the changing power of the Geyser. When



GREAT GEYSER, ICELAND.

first discovered they rose to the altitude of three hundred and sixty feet. In 1804, Lieutenant Ohlsen, a Danish officer, measured the height of the column by a quadrant, and found it to be two hundred and sixty feet. At the present time the average height is about ninety feet.

8. Theory of Geysers.—The waters of the geysers acquire their heat from hot volcanic rocks with which they come in contact. The experiments of Bunsen show that the eruptions are caused by the sudden formation of steam, deep in the spring, from water that has been heated to a temperature above its ordinary boiling point.

The water thus heated does not boil at 212° , the temperature at which steam forms under ordinary circumstances, because the great weight of the water in the upper part of the geyser-tube prevents the formation of steam.

When, finally, the boiling temperature is reached, the accumulating steam forces a part of the water out of the geyser-tube, and, the pressure being removed, the rest of the water flies into

¹ The "Great Geyser" is situated within a large circular mound, formed of the silicious deposits of the spring. At the top of this mound, when the fountain is at rest, is a basin fifty feet in diameter filled to the depth of several feet with hot water, clear as crystal, and gently bubbling. In the centre is a funnel-shaped opening, ten feet in diameter, which, widening out at the top, forms the basin.

² All the phenomena of a geyser eruption may be produced by heating the stem of a clay tobacco-pipe red hot and holding it in a horizontal position while the bowl of the pipe is filled with cold water.

steam—not gradually, but instantly, and with explosive violence, thereby causing an eruption.²

9. Mineral Springs.—On account of the great solvent properties of water, all springs are more or less charged with mineral matter; but when they are very strongly impregnated, they are called *mineral springs*. These are designated according to the prevailing ingredients they contain, as *Chalybeate*, *Saline*, *Silicious*, *Acid-Soda*, and *Sulphur Springs*.

Chalybeate, or iron, springs frequently contain so large a quantity of the salts of this metal that they encase the channels through which they pass with incrustations of oxide of iron.

Saline, or salt springs exist in various parts of the world. Those of Norwich, England, rise through beds of rock-salt, and are so richly impregnated that they yield an annual supply of nearly 40,000 tons.

In the United States there are very productive salt springs at Syracuse, New York, and at Abingdon, Virginia. Other springs of this class contain salts of magnesia, lime, and various other soluble mineral substances.

Silicious springs hold siliceous, or flint, in solution. They are very rare, being found only in connection with volcanic rocks. The Geysers of Iceland, as we have seen, are springs of this class; and, so far as is known, none but silicious springs ever become geysers.

Calcareous springs are those whose waters are impregnated with lime. Of all minerals, carbonate of lime is most abundant in springs. The hot springs of Vignone, Tuscany, deposit every year a layer of solid matter six inches thick.³

Sulphur springs are charged with hydrogen sulphide and other sulphur gases. They are readily detected by their offensive odor. Virginia, Colorado, and California are noted for springs of this character.

Acid-Soda springs are efficacious for medicinal purposes. Their waters are impregnated with the salts of soda and other alkaline metals. They hold in solution, also, more or less carbon dioxide. The water of acid-soda springs is cold.

Among the most famous acid-soda springs are those of Carlsbad, Selters, and Spa, on the continent of Europe, and those of Tunbridge and Cheltenham, in England. In the United States the principal springs of this class are those of Saratoga, in New York. They are also common in Virginia, Kentucky, and the Pacific highlands.

10. Petroleum Springs.—Natural and artificial springs of petroleum, or rock-oil,⁴ occur in many parts of the globe. In Birmah, along the Irrawaddy River, are at least five hundred wells. Numerous springs of this kind occur throughout the West Indies. In Trinidad, springs of this character have formed a bituminous lake three miles in circumference. In Texas and California petroleum springs are likewise found. But the most remarkable locality is the region embracing the western part of Pennsylvania and West Virginia. Natural oil-springs here

³ At Hierapolis, formerly a flourishing city in Asia Minor, the warm springs that burst from the neighboring cliffs are said, by ancient writers, to have been so highly charged with mineral matter that, when their waters were conducted through the vineyards and gardens, the channels became long walls, each consisting of a single stone. At present the spring branches out into numerous rills, and a limestone cliff has been formed by the mineral deposits.

⁴ Refined petroleum is the kerosene, or coal-oil, of commerce. It was formerly obtained by distilling bituminous coal.

occur, and numerous artesian wells have also been sunk. From some of the latter the oil flows spontaneously, and from others it is raised by pumping. The amount of oil obtained in this region is almost fabulous.

In boring for oil, inflammable gas and salt water are frequently ejected the moment the vein is struck. Sometimes the stream becomes ignited, and the column of flame shoots upward to a height of several hundred feet.

CHAPTER II.

LAKES.

1. A **Lake** is a standing body of either fresh or salt water, of considerable size, nearly or quite surrounded by land, and not



LAKE BAIKAL, EASTERN SIBERIA.

directly connected with the sea or any of its branches. It bears the same relation to a continent that an island does to the ocean.

2. **Origin of Lakes.**—Much of the water that falls from the clouds returns to the sea in rills, brooks, creeks, and rivers. On its way to the sea it flows through various depressions, many of which are large basins.

When more water flows into such a basin than can evaporate, a lake is formed. Usually the basin fills until the water reaches the lowest part of its rim; it then overflows. Thus, the lake may be considered as a widened part of the river channel. Not infrequently a river consists wholly of a chain of lakes, as is notably the case with many of the water-courses of North America.

In other cases, evaporation is so rapid that the water cannot fill the basin to the point of overflowing, but spreads over the

basin until the inflow and the evaporation balance each other. The size of the lake varies, therefore, with the rate of inflow of water. It may, at times, become dry; or it may, during seasons of excessive rainfall, overflow its basin.

It is evident, then, that two classes of lakes may be distinguished—those with outlets, and those without them. The waters of the former are fresh; the latter are salt lakes.¹

There are many lakes which have outlets, but no visible inlets. They are situated usually at high elevations, and have their sources in subterranean springs and in the rains and snow of the neighboring lands.

Lake Sir-i-Kol, situated on a table-land called the "Roof of the World," belongs to this class. It is the highest lake on the globe, being 15,600 feet above the sea-level, and is the source of the river Amoo. It covers an area of fourteen square miles. This lake receives a never-failing supply of water from the snow-capped mountains which encircle it and rise to a height of 3500 feet above its level.

Lakes which both receive and discharge streams of water constitute by far the greatest number. The chain of the great lakes of North America presents the finest instances of this class. A large number of streams pour into these inland seas, and the surplus waters give rise to the St. Lawrence River.²



LAKE OULUNJOUR, MONGOLIA.
(As seen from a cave in the surrounding rocks.)

3. **Distribution of Lakes.**—Lakes abound in all parts of the earth, but, except the African lake region, it is probable that

ing over submerged mountains and plains; and so clear is the water that the shells upon the bottom are perfectly visible at the depth of one hundred and twenty feet. Some lakes, though small, are of great depth: such is the Altyn Kool, or Golden Lake, of Siberia, one of the most beautiful in the world. It occupies a vast chasm in the Altai Mountains, of such profound depth that the bottom in some parts cannot be reached by a sounding-line 2000 feet in length. Lake Constance, in Switzerland, is at one point more than 2000 feet deep; and the Lake of Nemi, in Italy, attains the great depth of 2700 feet.

¹ Salt lakes are often called "steppe" lakes, because of their frequent occurrence in the steppes of the Eastern Continent.

² Many lakes are noted for the purity and brilliancy of their waters. Those of Great Bear Lake are of a light-blue tint, and so clear that a white object can be seen at the depth of ninety feet. Lakes Superior and Huron are remarkable for their transparency, rocks and fish being seen at extraordinary depths; and the waters of Lake George, so famed for its picturesque beauty, possess the same property. But nothing can exceed the transparency of the Norwegian lakes. The voyager appears to be sail-

more than nine-tenths of them are north of the 40th parallel of north latitude. In the northern part of North America alone there are estimated to be nearly 100,000.

Most of the lakes may be grouped in well-defined systems which occupy lines of depressions in the earth's surface. There are three of these systems in the Eastern and two in the Western Continent.

4. Lakes of the Eastern Continent.—The principal system of the Eastern Continent comprises a belt of lakes extending from Great Britain along the south shore of the Baltic, and thence across Finland, Northern Russia, and Siberia. Lakes Onega and Ladoga, in Russia, are among the largest belonging to this system.

The second system—which likewise ranges eastward through Europe and Asia—lies south of the former, following the great mountain-ranges. It embraces the lakes of high Europe and those of Western and Central Asia. The Caspian Sea, Aral Sea, and Lake Baikal are the largest of this system.¹

The European lakes of this system consist of fresh water; but many of the Asiatic lakes are salt or alkaline.

The third lake-system of the Eastern Continent is in Africa, and consists of the chain of fresh-water lakes discovered by recent explorers. The most important of these are Victoria Nyanza, Albert Nyanza, Tanganyika, and Bangweolo.

Victoria Nyanza and Albert Nyanza are the sources of the Nile. The former is the largest lake in the world. The main stream of the Nile issues from Albert Nyanza, and from this point the river has been followed to the sea.

The head-waters of the Congo and several of its tributaries consist of irregular chains of lakes. Next to Victoria Nyanza, Lakes Tanganyika and Nyassi are the largest African lakes.²

Lake Tchad, in Soudan, is a large expanse of fresh water. It is shallow, and subject to great fluctuations in size. During the rainy season it overflows through the Bahr el Ghazal.

5. Lakes of the Western Continent.—In number, the lakes of the Western Continent far exceed those of the Eastern. They are embraced mainly under two systems.

The first extends over the Great Northern Plain, and includes the chain formed by Lakes Superior, Michigan, Huron, Erie, and Ontario, whose united areas are greater than the area of all the remaining fresh waters of the globe. Lake Superior exceeds all the others in magnitude, having an area of 32,000 square miles. With the exception of Erie, all of them are deep.

This system forms an immense network of lakes, which spreads throughout British America to the Arctic Ocean. A line drawn from the city of Buffalo to the mouth of the Mackenzie River passes through nearly all the principal lakes of North America. Among the largest of these, besides the five already named, are Athabasca, Winnipeg, Great Slave, and Great Bear Lakes, which range in area from 3000 to 19,000 square miles.

The second system extends from the Columbia River to Panama, passing through the Great Basin. It comprises the

lakes of Utah, Mexico, and Central America, many of which are salt. The largest are Lake Nicaragua, Great Salt Lake, and Lake Chapala.

Few lakes of any notable size are found in South America. The largest is Lake Titicaca, in Bolivia, which is situated at the height of nearly 13,000 feet above the sea.

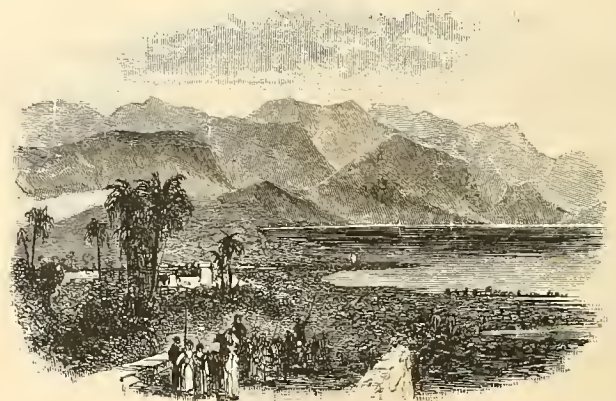
The lakes at the eastern base of the Andes are transient in their character, being nothing more than marshes and pools in the dry season, but spreading out into vast shallow sheets of water during the rainy period.

The lakes of Australia are of a similar nature, the large lakes being changed in the summer into a series of small ponds. Lake Eyre, the largest, is very shallow, and is broken up in the dry season into numerous pools.

6. Salt Lakes.—Lakes of this kind are most abundant in the vast steppes of Asia and the Great Basin of North America. There are a few groups in Mexico and Central America. The most remarkable instances are the Caspian, Aral, and Dead Seas,³ and Great Salt Lake. Salt lakes have no outlets. The waters of many such lakes are alkaline.

The Caspian Sea covers an area of 120,000 square miles, and its surface is eighty-four feet below the sea-level. Near the middle it is more than 2800 feet deep. It drains in Europe alone 850,000 square miles of surface. The Volga, the largest river in Europe, flows into it. Notwithstanding this immense influx, more water is lost by evaporation than is received, and this sea is gradually diminishing in size.

The Dead Sea, which is 1302 feet below the level of the Mediterranean, receives the Jordan and other streams. Its



THE DEAD SEA.

waters, which are exceedingly salt and bitter, contain twenty-six per cent. of mineral salts.⁴

Great Salt Lake is the largest body of salt water in the Western Continent. Its waters contain twenty-two per cent. of salt, and are so dense that a person can float upon them without an effort. Its rocky shores are encrusted with salt, and its shallow bays are covered with it for miles. Throughout this

and Lake Bangweolo, the source of the Congo, by Stanley. Lake Nyassi was first explored by Livingstone.

³ Although called *seas*, these bodies of water are lakes.

⁴ Among other salt lakes of the Eastern Continent are Lakes Elton and Urumiyah. The former is situated east of the Volga, and varies considerably. Its waters are very salt, and the Russians here obtain their largest supplies of this mineral. Lake Urumiyah, in Persia, is three hundred miles in circumference. Its beach is a solid pavement of salt.

¹ Lake Baikal is called by the natives the Holy Sea. It lies amid lofty granite mountains, at the height of about 1800 feet above the sea. It is the largest mountain-lake in the world, having an area of not less than 14,000 square miles. Even when the atmosphere is most calm, its waters are seldom without a wave; but during high winds it is the scene of violent storms.

² Victoria Nyanza was discovered by Speke in 1859; Albert Nyanza by Baker, four years afterward. Lake Tanganyika was discovered by Burton,

region saline lakes abound, which receive the waters of a considerable number of rivers and streams.

7. Origin of Salt Lakes.—Many of the mineral salts contained in the crust of the earth are readily dissolved in water, and thus the water filtering through the soil becomes charged with saline matter. It is therefore evident that the mineral salts must accumulate in the lake-basin, since all the water evaporated is pure, while the saline matters are left behind. If the evaporation should at length exceed the inflow, these lakes form strata of rock-salt.

Some of the largest salt lakes, as the Caspian and Dead Seas, occupy basins below the sea-level; but this is by no means a necessary condition, for salt lakes are found at all heights. In lakes which have outlets no such accumulation of saline matter can occur, and their waters are consequently fresh.

8. Advantages of Lakes.—The numerous lakes scattered over the surface of the globe fulfil important purposes in the economy of the world. They serve as vast reservoirs for storing up the superabundant waters of the wintry season against the heat and droughts of summer. Not only do they furnish the supply of water for the outflowing streams, but they also fill the atmosphere with moisture, and temper the dryness of the surrounding country.

CHAPTER III.

THE PHYSIOGRAPHY OF RIVERS.

1. Rivers are streams of water flowing into the ocean, into a lake, or into another stream.¹

2. Sources.—Rivers originate in springs and lakes, or in the ice-fields and glaciers of snow-capped mountains. The waters of several rills flowing together form a brook; and brooks uniting with others soon swell the stream into a river.

The overflow of lake-basins gives rise to many of the largest rivers of the globe. The Mississippi has its source in a series of lakes, the highest of which is Elk Lake. The surplus water of the Great Lakes forms the St. Lawrence.

A cluster of lakes in the Andes Mountains is the source of one of the larger tributaries of the Amazon River. The lake region of Central Africa is drained by the three largest rivers of that grand division—the Nile, the Congo, and the Zambezi.²

The glaciers and ice-fields that clothe the sides of lofty mountains also give birth to important rivers. The source of the Ganges is among the glaciers of the Himalaya Mountains, nearly 14,000 feet above the sea.

The Rhone, one of the chief rivers of Europe, springs from a glacier west of St. Gothard, 5500 feet above the level of the sea, and many of the tributaries of the Danube have their sources among Alpine glaciers.

3. Basins.—The region drained by a river and its tributaries is called its basin. Each tributary rill, brook, and minor river has its own basin; and their united areas constitute the basin of

the main stream. The size of a river-basin depends, in general, on the position and extent of the mountain-systems. Europe has the smallest basins, Asia the next in magnitude, and America the largest—the basin of the Amazon, with its network of rivers, having an area of not less than 1,500,000 square miles.



SOURCE OF THE GANGES.

4. Divides.—The elevated land which separates one basin from another is called a divide, or water-shed, inasmuch as the springs and streams here flow in different directions into the river-basins lying on the opposite sides. The roof of a house is a common and apt illustration of this feature.

Water-sheds are sometimes formed by mountains, and very often by moderate elevations in the great plains of the globe. Thus, in the Rocky Mountains, only a few miles apart, are the head-waters of the Columbia and the Missouri River—the one flowing into the Pacific Ocean, the other into the Gulf of Mexico.

The region where the Mississippi has its sources presents an example of the other kind of water-shed. A ridge of land here, about 1700 feet high, divides two great basins—the waters on the north side flowing into the Arctic Ocean and Hudson Bay, and those on the south into the Gulf of Mexico.

In Eastern Europe, a low rise of land, extending from the Carpathian Mountains to the Valdai Hills, forms a water-shed which separates the waters flowing into the Baltic Sea from those that enter the Caspian Sea.

Where the divide is low and level, barges are carried over from one basin to the other; and in some instances the elevation is so slight that a heavy rain will unite the waters of the contiguous basins. In the region which divides the head-waters of the Mississippi and the Northern Red River, boats are said to pass without interruption from basin to basin at times when floods prevail.

It is usually somewhere in the mountain-system, but it rarely coincides with the highest ridge. The sources of the large rivers of Asia are north of the Himalaya Mountains. Many of the large rivers of the Atlantic slope of North America rise west of the main crest of the Appalachian system, while a few of the tributaries of the Mississippi, as the Great Kanawha, have their sources east of it.

¹ In some cases they are absorbed in sandy deserts; thus, the streams of Central Arabia, which descend towards the Persian Gulf, are lost in the intervening deserts; and the river Desaguadero, that issues from Lake Titicaca, sinks in the wastes that lie south of the lake.

² It is a very prevalent error to regard divides as identical with the main crests of mountain-chains. The dividing line between river sources

There are examples even of river-basins so running into each other that a natural water-communication exists between them. The most remarkable instance of this nature occurs in South America, where the Cassiquiare River connects the adjacent



NIAGARA FALLS, NIAGARA RIVER.

basins of the Orinoco and the Amazon. It is one hundred yards wide where it leaves the Orinoco, and five hundred and fifty where it flows into the Rio Negro, a tributary of the Amazon.¹

5. Courses.—River-courses vary in their physical features in different parts of the stream. In the upper course, a river generally flows in a deep and rapidly-sloping channel, the stream either rushing through narrow gorges of its own cutting, or leaping in cataracts down precipices.

Lower down, in its middle course, the river loses its violence, and, becoming broader, flows with a more peaceful current.

In its lower course a river flows generally through a plain built of the sediment brought down by its own current. Its bed being almost level, the motion of its waters is scarcely perceptible. At its outlet it diverges into many minor streams.

6. Deltas.—A river which flows through an alluvial region brings down in its current a vast amount of sediment, which is deposited at its mouth. Marshes, shoals, and islands are thus formed, through which the river, branching into numerous streams, forces its way. This network of land and water constitutes a triangular figure, termed a *delta*.²

The Ganges, which carries down annually 534,600,000 tons of solid matter, has formed a delta, called the Sunderbunds, 200 miles long and 180 broad. The Nile has a delta more than 170 miles in length. The delta of the Mississippi comprises 14,000

square miles, and this great river bears yearly to the Gulf of Mexico an amount of sediment sufficient to cover a square mile of land to the height of 268 feet.

Deltas are also formed on a smaller scale where a tributary enters the main stream, and at the junction of a river with a lake. Thus, the Volga has a delta at its outlet, discharging its waters into the Caspian through seventy mouths.

7. Velocity.—The velocity of a river depends much on the form of its channel and the volume of water. It depends chiefly, however, on the inclination of its bed. The amount of sediment borne by the water is governed almost entirely by the velocity of the current.

If the current be increased, it will not only carry more sediment, but it will cut away its banks and bed to obtain it. If the current be checked, the water can no longer carry so much sediment; it must, therefore, drop a part of it and flow around it.

Thus, along the lower course of a river, during seasons of low water, the river has a tendency to lengthen its channel, while at a season of high water its current is swifter, and it carries away the sediment it formerly deposited, thereby shortening its course.³

When the inclination of the channel is great, *rapids* are caused, around which navigation is conducted by canals. In some cases the flood-tide rises over the rapids in the lower part of a river, thus removing at intervals the obstructions which they have created.

The cataracts of the Nile, which are properly rapids, extend throughout the river for more than two hundred miles. They



VICTORIA FALLS, ON THE ZAMBEZI RIVER, AFRICA.

consist of nine or ten sloping descents, none of which is more than a few feet high. The Columbia flows for many miles of its course in a succession of cascades and dalles to the Pacific.

¹ For the purposes of navigation, river-basins are frequently united by canals. The Erie Canal, which is one of the longest in the world, and is the route of an immense inland trade, connects Hudson River with Lake Erie, the natural outlet of whose water is the St. Lawrence. This latter stream is also united to the Mississippi in several places by means of important canals.

² So called from its resemblance to the Greek letter *Delta*, Δ .

³ The Amazon for the last seven hundred miles of its course falls but one-fourth of an inch for every mile and a quarter; the La Plata for four hundred miles from its mouth descends only one-thirty-third of an inch per mile; while the Ganges has scarcely any perceptible fall for the last 1300 miles of its course.

But none exceed in sublimity and grandeur those of the St. Lawrence, the principal of which are the Long Saut and La Chine. In the former, the river descends with tremendous speed



YOSEMITE FALLS, CALIFORNIA.

for the space of nine miles in one continuous rapid, being divided into two channels by an island. In the southern channel, which is very narrow, the velocity of the current is more than fifteen miles an hour.

The rapids of La Chine are so swift that a canal has been constructed around them, as vessels are unable to stem the current. The rapids of Richelieu,

between Montreal and Quebec, occur at ebb and disappear at flood tide, the river rising from the latter cause to a point higher than the head of the rapids.

8. Falls.—When the inclination of the channel of a river is so great that it is nearly or quite perpendicular, *falls*, or *cataracts*, are caused. They occur in every part of the world, and are phenomena of great beauty and sublimity. Some are remarkable for their height, others for their volume of water; in the finest, both these characteristics are combined.¹

Of all cataracts, the Falls of Niagara are generally regarded as the grandest. The surplus waters of the four great northern lakes form the Niagara River. This stream, issuing from Lake Erie, descends at first in a series of rapids fifty feet in less than a mile, and then plunges over a precipice more than one hundred and sixty feet high.²

The Victoria Falls, on the Zambezi River, in Africa, vie in magnificence with the Falls of Niagara. They are caused by the descent of the Zambezi into a perpendicular chasm formed in hard basaltic rock. The chasm is eighty yards wide at its narrowest part, and into this abyss the river plunges, with a deafening roar, from a height of three hundred and sixty feet.

Yosemite Valley, California, abounds with many beautiful cataracts, distinguished for their height, the most remarkable of

which are Yosemite Falls. These falls are formed by the Merced River, which plunges in three successive leaps over a rocky precipice into the valley, 2600 feet below.

The first cataract is 1500 feet high. From its foot the stream rushes through a deep, water-worn gorge, and descends by a fall of 600 feet to the next ledge, where it makes its final plunge of 500 feet into the valley beneath.³

In dry seasons the stream of the highest fall is dissipated into spray before it reaches the base; but at other times the torrent descends unbroken from summit to base, forming, in many respects, the most remarkable water-fall in the world.

9. Cañons.—The current of a river is usually but a few feet below the surface of the region through which it passes; but in some cases the turbulent waters have worn channels of immense depth, and flow through narrow rocky gorges thousands of feet below the general level. This peculiarity in a river-channel is termed a *cañon*.

Cañons abound in the region west of the Rocky Mountains, occurring throughout the entire region, and especially along the upper courses of the Rio Grande, Crooked, and Columbia



GRAND CAÑON, COLORADO RIVER.

Rivers. But nowhere else are they developed on such a scale of grandeur as on the Colorado and its tributaries. For more than 1000 miles this great river descends through a channel

¹ The Falls of Trenton, in New York, are distinguished for their wild and picturesque beauty. Those of the Passaic River, in New Jersey, are 70 feet high; and the waters of the beautiful cataract of Montmorency, near Quebec, descend 250 feet in one unbroken sheet. Of a sterner character are the Falls of St. Anthony, where the entire Mississippi descends 17 feet; as are also the cataracts of the Missouri, where the great river, after bursting the barriers of the Rocky Mountains, leaps down in a series of rapids and cataracts 360 feet, the three greatest falls having the respective altitudes of 87, 47, and 26 feet. The Grand Cañon of the Gunnison River is celebrated for the numerous cascades which plunge over its precipitous sides. The Cascade Range receives its name from the multitude of water-falls along its flanks.

² The river at the Falls is about three-quarters of a mile broad, and the precipice curves in the form of a semicircle. Goat Island divides the cataract into two portions—the American Falls, and the Horse-Shoe Falls on the Canada side. The breadth of the former is 1000 feet, and its height 164 feet; the latter is 2000 feet across, and 158 feet high. It is estimated that more than 20,000,000 cubic feet of water flow over Horse-Shoe Falls each minute. On the verge of the fall the sheet of water is at least eighteen feet deep.

³ Merced River is a small stream, about equal, at the close of the summer, to three or four ordinary mill-brooks; but in the spring, when the sun melts the snows at its source, it swells to a torrent.

whose perpendicular walls are, in places, nearly a mile and a quarter high.¹

10. **Magnitude.**—The size of a river depends upon the extent of its basin and the amount of the rainfall and evaporation therein. These factors combine in their fullest development in such rivers as the Amazon,² the Mississippi, and the Congo.

11. **Changes in Volume.**—The changes in the volume of a river are caused by the tide, by the melting of snow and ice, and by the recurrence of heavy rains at stated seasons.

The influence of the tide is exerted daily and monthly—the high and the low tides occurring twice a day; the spring and the neap tides twice a month. Consequently the lower courses of those streams which flow into the ocean have their levels considerably affected by this cause.

Where rivers descend from mountains that tower above the limit of perpetual frost, a daily rise takes place in the upper part of the stream, from the melting of the snow—the increase being greatest during the hottest days. Such is the case with many rivers among the Himalayas and in some parts of Africa.

In Peru and Chili there are small rivers which run only in the day, being fed solely by the melting of the snows. In the Great Interior Basin of the United States, on the contrary, during the hot and dry summers, many of the streams disappear entirely during the heat of the day, when evaporation is greatest, and flow only at night.

In countries where the year is divided into rainy and dry seasons, rivers are subject to changes in height, which arise from two distinct causes—the melting of the snow in spring and summer, and the fall of rain during the wet season. The rivers which are affected by both these causes have semi-annual floods; and those which are influenced by the latter only, annual periods of high-water.³

In the Mississippi the first and smaller flood occurs in January, and is caused by rains. Its chief rise, which results from the melting of the snows, occurs from April to June. The river then swells in some places to the height of forty or fifty feet above its ordinary level, expanding into lagoons and bayous from thirty to one hundred miles wide.

The greatest river-floods are annual; and the most remarkable of these occur in the plains of South America. The Orinoco, which rises with the coming of the rainy season, floods the surrounding plains to the depth of from twelve to fourteen feet,

¹ The two most remarkable gorges of the Colorado are Grand and Marble Cañons. Marble Cañon is near the mouth of Little Colorado River. Its walls are here more than 3500 feet high. "No description," says Lieutenant Ives, the explorer of this river, "can convey an idea of the varied and majestic grandeur of this peerless water-way. Wherever the river turns, the entire panorama changes. Stately façades, august cathedrals, amphitheatres, rotundas, castellated walls, and rows of time-stained ruins, surmounted by every form of tower, minaret, dome, and spire, have been moulded from the Cyclopean masses of rock that form the mighty defile." Grand Cañon begins near the mouth of the Diamond River. At this point its walls have an altitude of 3000 feet. But a few miles farther eastward the table-land rises to the altitude of 6200 feet above the sea, and the vast cliffs of the cañon tower to the height of more than a mile above the stream. The scenery resembles that of Marble Cañon, but it is on a more colossal scale. "It is," says Lieutenant Ives, "the most magnificent gorge, as well as the grandest geological section, of which we have any knowledge. For 1000 feet above the river the cliffs are composed of granite. Next above this are strata of sandstone, limestone, and shale, 2300 feet in thickness; and higher still appear the carboniferous series, more than 2000 feet thick, consisting of limestone, sandstone, and gypsum, apparently all marine, and highly fossiliferous."

² The Amazon is the mightiest river in the world. Its length is 3600

covering an area six hundred miles long and nearly one hundred miles in width.⁴

But the most remarkable of all annual floods is that of the Nile, which has recurred with the utmost regularity for thousands



OVERFLOW OF THE NILE—SUEZ RAILROAD.

of years. It results from the periodical rains which fall in torrents upon the plateaus of Abyssinia. The inundation of the Nile begins near the middle of June, and continues to increase until the middle of September. It then remains stationary for a few days, when it begins to subside, diminishing till about the middle of December.

To the rise of the Nile Egypt owes its extraordinary fertility, the river spreading upon its plains the enriching sediment brought down from the mountains.⁵

CHAPTER IV.

THE DISTRIBUTION OF RIVERS.

1. **Rivers** are classified with reference to the distribution of their waters. Those whose waters reach the ocean or any of its arms are called *Oceanic Rivers*. All others are known as *Continental* or *Inland Rivers*.

miles; its basin is about eight times the size of France; the broad sweep of the northeast trade-winds, loaded with moisture, drenches the region which it drains; interminable forests check evaporation from the dank soil; and its sources are hidden amid the snowy heights of the Andes. In the upper part of its course it is from one to two miles in width; while its banks where it enters the Atlantic are distant from each other more than one hundred miles. At a distance of 2000 miles from its mouth it is navigable for vessels of any burden.

³ The Tigris rises twice a year—first in April, on account of the melting of the snow in the Armenian mountains, and secondly in November, when a smaller rise is caused by the periodical rains.

⁴ The Amazon being in the southern tropic, while the Orinoco is in the northern, the dry and wet seasons are interchanged. The rise of the former is greatest in March, and least in July and August.

⁵ The casual variations in the level of rivers arise from occasional strong winds and heavy rains. Thus, a strong easterly wind causes a rise in the waters of the St. Lawrence. A violent easterly wind checks the current of the Orinoco to such an extent that, in the upper part of its course, the waters are forced back into the tributary streams, reversing their currents and causing inundations. Under the pressure of a north wind the Baltic Sea is driven up the Oder River, and swells its stream to a considerable distance.

OCEANIC RIVERS.

Oceanic rivers are comprised in four systems, each being designated by the name of the ocean into which its rivers flow.

1. Arctic System.—This division embraces all the rivers that flow into the Arctic Ocean from the northern slopes of the two hemispheres.

The Obi drains about one-sixth of Siberia, its basin having an area of nearly 1,000,000 square miles.

The Yenisei receives many tributary streams, which in their middle and upper courses are impetuous torrents. The basin of this river is 784,000 square miles in extent.

The Lena rises in the mountain-ranges near Lake Baikal, and, after receiving various affluents, enters the ocean through a vast delta, descending between banks of frozen mud and sand.

In the Western Continent, few streams flow into the Arctic Ocean. The principal are the Mackenzie, Coppermine, and Great Fish Rivers. Of these the Mackenzie, which is the largest, drains an area of nearly 500,000 square miles.

The rivers of this system are of little importance except for drainage. They are frozen in their lower course for half the year, and are, therefore, useless for navigation. When the melting of the snows at their sources sends down a flood, their ice-locked mouths check the swelling waters, and cause inundations, transforming the neighboring plains into desolate tundras.

2. Pacific System.—The river-system of this mighty ocean is altogether disproportionate to its own extent. In the Western Hemisphere the only rivers of any note are the Yukon, Colorado, and Columbia.

The Yukon drains the territory of Alaska. This river discharges a greater volume of water than any other river in North America. It is 2040 miles long. Its average width along the lower course is from three to four miles.

The Colorado drains most of the region between the Rocky and the Sierra Nevada and Cascade Mountains. Throughout the greater part of its course it flows in deep cañons. The area of its basin is 170,000 square miles.

The Columbia, after an impetuous course of cataracts and rapids between walls of rock 2000 feet high, enters the Pacific below Astoria.

In the Eastern Continent many large rivers fall into the Pacific, since the great mountain-ranges are there situated farther inland than those of America. Chief among these are the Amoor, Hoang-Ho, Yang-tse-Kiang, and Mekong.¹

The Amoor, after a course of 2200 miles, enters the Sea of Japan. Its basin is the granary of Siberia, and the river itself is the chief thoroughfare of Asiatic Russia.

The Hoang-Ho and Yang-tse-Kiang are the great rivers of China. They rise in the mountains of Tartary, and, traversing the Chinese plain, enter the Yellow Sea only ninety miles apart. They are both navigable for vessels of considerable size for 600 to 800 miles.

¹ These rivers are liable to great changes in their lower courses. In 1851 the Hoang burst its barriers, and flowed through a new channel to the Gulf of Pechelée, more than two hundred miles from its former mouth.

² Its source, Lake Bangweolo, was discovered by Livingstone, the famous explorer. This river drains by far the most fertile region in Africa.

³ There is strong evidence that the Saskatchewan River was once the upper part of the Mississippi, and that the rising of the Height of Land ponded its waters, forming Lake Winnipeg. The old channel may yet be traced through Minnesota.

3. Atlantic System. The largest rivers of the globe flow into the Atlantic Ocean. This system therefore includes the territory drained by Hudson Bay, by the Gulf of St. Lawrence, and by the Baltic, Mediterranean, and Black Seas.

The Danube, winding from its source in the Black Forest, enters the Black Sea, after draining a region more than 200,000 square miles in extent.

The Nile has its sources in Victoria Nyanza and Albert Nyanza, and, after flowing about 3600 miles, enters the Mediterranean through the two principal mouths of its delta, at Rosetta and Damietta. For the last 1200 miles it does not receive a single affluent.

The Congo, sometimes called the Livingstone River, drains a territory nearly equal in size to that drained by the Mississippi.²

The Niger, descending from the northern slopes of the Kong Mountains, flows for 2600 miles in a winding course to the Gulf of Guinea, entering the Atlantic through a delta 32,000 square miles in extent. This stream is from one to six miles wide, and is navigable for several hundred miles from its mouth.

The Saskatchewan rises in the Rocky Mountains, and enters Lake Winnipeg, whose waters are discharged into Hudson Bay through the Nelson River.³

The St. Lawrence, at first called the St. Louis, enters Lake Superior at its western extremity. Bearing off the surplus waters of the great northern lakes, it issues from Lake Ontario at Kingston, where it receives the name of the St. Lawrence.⁴ It enters the Gulf of St. Lawrence by an outlet more than one hundred miles broad.



THE SOURCE OF THE MISSISSIPPI.

The Mississippi,⁵ the longest river of the world, spreads fertility over the valley through which it flows, and bears upon its waters

⁴ The Saguenay joins the St. Lawrence about 120 miles below Quebec. For a distance of seventy miles from its mouth the Saguenay flows, a mile in width and 1000 feet deep, between walls of rock 1000 feet high, and, apparently, fills an immense chasm formed by a rupture in the mountains of this region. At its outlet it is 700 feet deeper than the St. Lawrence, and in some places is nearly a mile in depth.

⁵ Recent surveys show that Elk Lake is several feet higher than Lake Itasca, and is, therefore, the source of the Mississippi River. Elk Lake is sometimes called Lake Glazier.

a vast internal commerce. This great stream, from the source of the Missouri, is 4200 miles long, and is navigable for a distance of nearly 4000 miles. It drains an area of 1,250,000 square miles. From its source to its mouth the Mississippi receives the waters of more than 1500 tributary streams, many of which are themselves large and important rivers.



THE HEAD-WATERS OF A RIVER.

The Orinoco, in South America, rises among the mountains of Parime, and drains a surface of 300,000 square miles. It is navigable for 1000 miles from its mouth.

The Amazon has its source in the Apurimac River, high in the Andes Mountains. After receiving numerous tributaries, more than twenty of which are navigable rivers, it enters the ocean by an estuary one hundred and thirty-five miles broad.

This great river drains an area of 1,500,000 square miles, and discharges such a vast flood into the sea that it freshens the waters of the latter hundreds of miles from the land. No other river in the world discharges such an enormous volume of water.

The La Plata drains the southeastern part of South America. It receives many tributaries in its course, the principal of which are the Paraguay and Parana. This river drains a region nearly 1,000,000 square miles in area, and enters the ocean by an estuary one hundred and twenty miles broad.

4. The Indian System.—The eastern coast of Africa, the southern slope of Asia, and the western part of Australia, discharge their waters into the Indian Ocean. The rivers of this system are not numerous, though generally of large size.

The Zambezi is one of the largest rivers of South Africa. It is navigable for nearly eight hundred miles.

The Tigris and Euphrates, forming a single river-system, rise in the mountains of Armenia, and, piercing the ranges of the Taurus, wind through the plains of Mesopotamia to the Persian Gulf. The united rivers drain a surface of nearly 200,000 square miles in area.

The Indus has its origin in the table-land of Thibet, and, after plunging down the high mountain slopes, reaches the plain of India. Here it receives the Punjab (or five rivers), which, like

the main stream, springs from the snows of the Himalayas. It enters the sea by an extensive delta. The Indus is navigable for vessels of small burden only.

The Ganges and Brahmaputra, the sacred rivers of the Hindoos, form a double river-system, and together drain an area of nearly 500,000 square miles. The Ganges, rising among the glaciers of the Himalaya Mountains, receives nearly twenty large tributaries, and flows through the alluvial regions of India, entering the Bay of Bengal by a wide and mazy delta.¹

The Brahmaputra has its source near that of the Ganges, but on the opposite side of the Himalaya range. Severing this mighty chain, it enters the delta of the Ganges about one hundred miles from the sea.²

The annual floods of these rivers overspread and enrich the lowlands of India for hundreds of square miles, and discharge such a volume of water into the Bay of Bengal that nearly all its upper area is freshened by it.

The Brahmaputra, from the swiftness of its current, admits of but little navigation. The Ganges is always navigable, and light vessels can ascend it to the very foot of the Himalaya Mountains.

The Irrawaddy has its source among the mountain-ranges that give rise to the eastern tributaries of the Brahmaputra. It is a rapid stream, flowing with a turbid current, and forming an extensive delta at its mouth.

In Australia the only important stream flowing into the ocean is the Murray River. The rivers of this continent are fed by rains, there being little or no snow at their sources. As a consequence, an Australian river is an impetuous torrent during the rainy season, and a succession of stagnant pools during the dry season.

5. Continental System.—A continental river-system is one whose streams either flow into a depressed basin, or steppe region, which has no connection with the ocean, or, flowing seaward, are swallowed up by intervening deserts.

The principal regions in which continental rivers occur are the basins of the Caspian, Aral, and Dead Seas, and the Great Interior Basin of the United States. There are a few such basins in Africa and Australia. The basin of Lake Titicaca, in South America, is sometimes considered a steppe region.



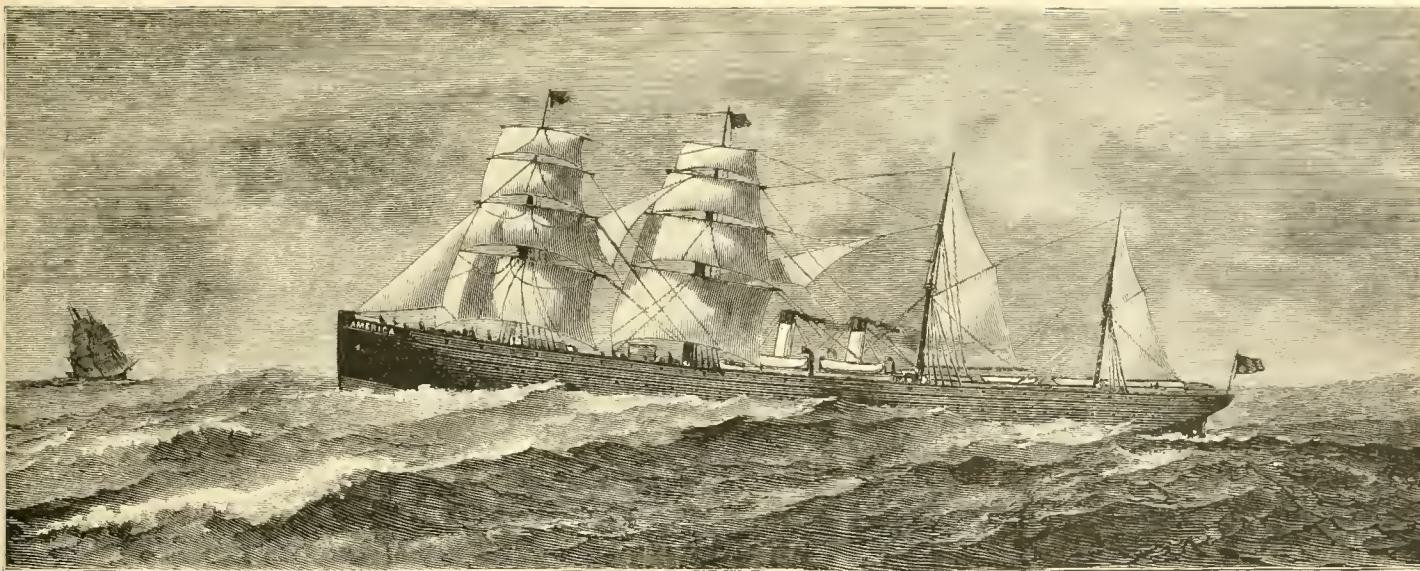
SCENE ON THE GANGES.

The Caspian and Aral system is the largest of this class. Several large rivers enter these lakes, the chief of which are the

is submerged. Not infrequently a large area is swept away by the waves and rebuilt in another place.

² The late surveys of the British Government have shown the San Po River to be the upper course of the Brahmaputra.

¹ The delta of the Ganges is larger than that of any other river. The upper part is covered with dense growths of timber. The lower part consists of shifting mud-banks, built from sediment scarcely heavier than the water itself. With every heavy storm much of the lower part of the delta



THE SEA.

Volga, Ural, Sihon, and Amoo. The Volga drains a region 400,000 square miles in extent, and enters the Caspian Sea by seventy mouths.

The Sir Darya and Amoo Darya flow into the Aral Sea. This system includes the minor basins of Central Asia, among them Lakes Balkash and Lop.

The Dead Sea receives several streams. The most noted is the Jordan, which rises in Syria, near the Anti-Lebanon Mountains.

The Great Interior Basin of the United States contains several rivers, of which the Humboldt is the largest. All of them flow into the lakes of this table-land.

From the ranges of the Andes many streams enter Lake Titicaca, Bolivia; but its only outlet is the Desaguadero, whose waters are lost by evaporation and absorption in the sandy wastes.

The central highlands of Arabia are abundantly watered by springs and streams. But none of the torrents that channel the hills find their way to the sea, all being absorbed by the sands of the desert.

The interior of Australia has been but little explored; but the knowledge obtained seems to warrant the conclusion that it constitutes a large continental basin, having marshes, salt lakes, and a system of internal drainage.

6. Importance of Rivers.—Rivers are the great natural highways through which commerce reaches the heart of a continent. The finest streams flow through the most fertile tracts; for the process by which rivers have been formed has given birth to the rich plains that border their banks. Transportation is thus provided for the excess of production that springs from the fruitful regions they traverse.

In the growth of new countries the first settlements have always been made along its river-courses, and so important are these to the prosperity of a people that in most countries rivers are under especial government control.

¹ In 1827 Parry travelled for a month over the ice, reaching latitude $82^{\circ} 40'$; but at this point the ice-fields drifted southward faster than he could advance northward. In 1871 Hall reached latitude $82^{\circ} 16'$, and in 1875 Markham succeeded in penetrating as far north as $83^{\circ} 20'$. In May, 1882, Lockwood and Brainard, of the Greely Expedition, travelled eastward along the northern shore of Greenland, reaching latitude $83^{\circ} 24'$. Pavy

CHAPTER IV.

THE OCEAN.

1. **The Ocean** is the expanse of water which encircles the continents and islands. Its great divisions correspond to the continents; its seas and gulfs, to the peninsulas; its lesser bays, to capes; and its straits, to isthmuses.

In the relief of the ocean the same law obtains. Its varying depths answer to the different heights of the land; for its bottom is diversified with plains, table-lands, and mountain-ranges whose summits, in many instances, emerge from the waves.

2. **Area and Divisions.**—The ocean embraces an area of 144,000,000 square miles, or about three-fourths of the entire surface of the globe. It is comprised under five great divisions, also called oceans, each having its own systems of seas, gulfs, and bays. These divisions are the Arctic, Atlantic, Indian, Pacific, and Antarctic Oceans.

3. **The Arctic Ocean.**—The Arctic Ocean surrounds the north pole, and is itself nearly enclosed by the northern shores of the two continents. It has an area of about 4,000,000 square miles. Many navigators have sought to reach through its waters the north pole; but the vast ice-fields that cover its surface have thus far frustrated every attempt.¹

The shores of this ocean are perpetually encased in ice. During the summer immense masses of this ice drift southward, and melt in the warmer waters of the Atlantic.² The east coast of Greenland is skirted by ice-cliffs for a distance of six hundred miles, caused by the freezing of the water which, in summer, flows from the melting snows of the interior.

4. **The Atlantic Ocean.**—The Atlantic Ocean is a lane of water extending from the Arctic to the Antarctic circle. It is bounded by America on the west, and by Europe and Africa on the east. It is 9000 miles long, varying in breadth from 900

and Rice of the same expedition, travelling over the ice in a northwesterly direction, reached Cape Aldrich, nearly as far north.

² The floating ice consists principally of two kinds, *field-ice* and *berg-ice*. The former masses, which consist of frozen salt water, are often of immense extent, sometimes having an area of one hundred square miles. The latter are formed on land.

to 4000 miles. It is divided by the equator into the North and the South Atlantic. The area of the Atlantic Ocean is about 25,000,000 square miles.

This ocean, lying between regions inhabited by the most civilized and enterprising nations of the earth, is the great highway of the commerce of the world. Its numerous inlets give access to the most productive regions, piercing deeply into the continents, thus affording remarkable facilities for traffic.

5. The Indian Ocean.—This ocean is bounded by Asia, Africa, Australia, and the Antarctic circle. It is more than 4000 miles wide, and has an area of about 23,000,000 square miles.

6. The Pacific Ocean.—The Pacific Ocean, the largest of the oceans, is a vast oval-shaped body of water, bounded by the Eastern Continent on the west, and by the Western Continent on the east. It is divided by the equator into the North and the South Pacific. It comprises nearly two-thirds of the surface of the entire ocean.

The Pacific Ocean contains comparatively few inlets of importance. In the western part are several large and partly land-locked seas.¹ It is noted for its numerous island groups.



THE ARCTIC OCEAN—NORTHERN SHORE OF GREENLAND.

7. The Antarctic Ocean.—This ocean is bounded by the Antarctic circle, and surrounds the south pole. It has the same character as the Arctic Ocean, but is more effectually ice-locked.²

¹ The Pacific was unknown to the civilized world until about three hundred and fifty years ago, when Vasco Nuñez de Balboa, having crossed the Isthmus of Darien, beheld, on the 13th of September, 1513, from a lofty mountain, the waves of this mighty ocean rolling before him. Seven years later, Fernando Magellan, seeking a westward passage to the Maldivé Isles, entered this ocean through the strait that bears his name. From the tranquillity of its waters he gave it the name of the Pacific. It is, however, subject to violent storms, though not to such an extent as the Atlantic and Indian Oceans.

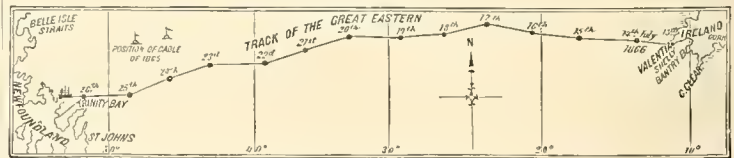
² In the year 1841 Sir James Ross passed through a field of floating ice eight hundred miles broad. He penetrated as far as 78° 10' south latitude, the highest point yet attained. The icebergs of this ocean are of different shape from those of the Arctic, having a tabular form. They drift down in immense numbers to lower latitudes than those of the northern seas, being met with as far north as the Cape of Good Hope and the mouth of the La Plata. An Antarctic iceberg was observed by D'Urville which was thirteen miles long, with perpendicular sides one hundred feet high. Its depth below the surface of the sea must, therefore, have been about eight

8. The Bed of the Ocean.—Soundings made in nearly every part of the ocean lead to the conclusion that the ocean-bed resembles the surface of the land, being diversified with valleys, slopes, table-lands, and mountains.³

The floor of the ocean is by no means so irregular, however, as the surface of the land, and, except in the vicinity of coral formations, the various surveys and soundings have not disclosed any abrupt changes of level.⁴ From Newfoundland to Ireland, along the line of the telegraph cable, there are but few inclines steeper than the grade of an ordinary carriage-road.



TELEGRAPHIC PLATEAU.



THE ATLANTIC CABLE.

9. Telegraphic Plateau.—Between Ireland and Newfoundland the bed of the Atlantic forms a wide and level expanse, in no place exceeding 13,000 feet in depth, covered with the broken shells of minute marine animals. This is termed the *Telegraphic Plateau*, and on this bed now rest the telegraph cables which unite the Eastern and Western Hemispheres.

10. Depths of the Ocean.—The average depth of the three larger oceans is not far from 15,000 feet. The Arctic Ocean is comparatively shallow, rarely exceeding 2000 feet in depth. The Antarctic Ocean is much deeper, but no soundings have been made whereby its average depth has been determined.

Land-locked waters have seldom any great depth. The Mediterranean Sea and the Gulf of Mexico exceed 12,000 feet in a few places only; their average depth is much less. The Red Sea is less than 3000 feet deep. The Baltic and North Seas are not more than 600 feet in depth.

Within a few years, methods have been perfected by Commodore Belknap, U. S. Navy, whereby deep-sea soundings are now made with a precision never before attained. A stout steel wire is substituted for the heavy wire cable or hempen rope, and the machinery for unreeling the wire is so regulated that it stops the instant the heavy sinker at the end touches bottom. A self-registering thermometer enables the observer to ascertain the temperature at any depth.

The deepest trustworthy soundings yet obtained were made

hundred feet. More recently icebergs of much greater height have been sighted by the steam-whalers which occasionally cruise in this ocean.

³ The basin of the Atlantic, which has been best explored, is found to be a deep valley, rising by a succession of irregular table-lands to the shores of the Eastern and Western Continents. From the researches of the Coast Survey between New Jersey and Block Island, it appears that the bottom of the ocean descends about five feet in a mile to the distance of 100 miles from the shore, being at this point 500 feet deep, but beyond this limit it descends 400 feet in a mile. The boundary-line of the first submarine plain, 6000 feet below the surface of the sea, is about 120 geographical miles from the present coast; and that of the second terrace, 6000 feet lower, is reached at the distance of 250 geographical miles.

⁴ During the surveys of the U. S. steamer *Tuscarora*, a group of six submarine mountains was discovered between the Hawaiian Islands and Japan. These mountains vary in height from 7000 to 12,000 feet. Their sides and summits were found to be clothed with coral limestone. Lava and a yellowish-brown soil were discovered in several of the valleys. It is inferred from this that the mountains were of volcanic origin.

off the Kooril Islands by the U. S. Steamer Tuscarora. Here a submarine valley, 27,930 feet deep, parallel to the coast, was partly surveyed. A similar depression north of Porto Rico has been recently discovered. In this locality the soundings vary from 22,000 to nearly 26,000 feet.

11. Saltness.—The waters of the ocean contain an average of 3.4 per cent. of mineral salts. Three-fourths of this is common salt. The remainder consists of compounds of lime, silica, potassium, sodium, iodine, bromine, and other elements.¹

The waters of land-locked seas in the north contain much less than the average percentage of salt, because of the vast amount of fresh water that is poured into them by the large rivers of the surrounding regions. Thus, the waters of the Baltic Sea contain less than 1 per cent. of salt.²

The enclosed seas of equatorial regions, however, contain much more than the average percentage, owing to the great evaporation. The water of the Red Sea contains 4.3 per cent.—more than five times as much as that of the Baltic Sea.³

The sea is freshened at a considerable distance from the outlets of large rivers. At the mouth of the Amazon, fresh water may be taken from the surface of the sea out of sight of land, and at the distance of three hundred miles from the shore the water is only brackish.

The cause of the saltness of the sea is not with certainty known. Vast deposits of rock-salt constitute a portion of the globe; and with these its waters may possibly come in contact. Moreover, for ages the rains have constantly returned in rivers to the sea, charged with the various saline ingredients which have been dissolved in them; while nothing but the purest water is returned by evaporation to the land, the foreign matter being left in the ocean.

12. Density.—Sea-water, bulk for bulk, is heavier than fresh water. A cubic foot of the latter weighs 1000 ounces; while the same quantity of the former has an average weight of about 1028 ounces.

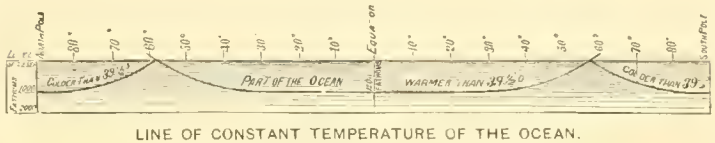
The density of sea-water varies also with its temperature. The warm waters of the tropical seas are considerably lighter, bulk for bulk, than the cold waters of the polar oceans. It is to this property, more than to any other, that the circulation of ocean waters is due.

13. Temperature.—The temperature of the ocean varies with latitude. At the equator the surface temperature is about

80°. Towards the poles the temperature gradually decreases, until, at about latitude 72°, it is only a few degrees above the freezing point.⁴

The surface temperature is not uniform for each degree of latitude, for, on account of the various ocean currents, belts of warm water are found in high latitudes, while areas of cold water are frequently met with in low latitudes.

The temperature varies also with the depth. At the bottom of the ocean the temperature ranges from 30° to 36° in all places where the depth exceeds 2000 fathoms. In shallow waters the range of temperature is much greater.⁵



The mean temperature of the surface of the sea at any point, when unaffected by currents, is nearly the same as that of the atmosphere above it. This temperature decreases with the increase of latitude, sinking gradually from the greatest equatorial heat of 89°, towards either pole, till the sea becomes frozen and covered with fields of ice.⁶

14. Color of the Ocean.—The color of the deep ocean is a rich blue. Shallow waters have a greenish hue; but the tint varies as the sky is darkened by clouds or glows in sunshine. On the Banks of Newfoundland the water has a peculiar green tint, which contrasts strongly with the dark blue color of the surrounding ocean.

Certain parts of the ocean assume different hues. The Red Sea contains a red coloring matter, thought to be of vegetable origin. In the Indian and Pacific Oceans long tracts of red, white, and brown water are frequently seen.

A large part of Baffin Bay has a deep olive hue, caused by the presence of marine animalcula; and a similar phenomenon, arising from the same cause, has been occasionally seen in other parts of the ocean.

15. Phosphorescence.—During the darkness of the night the sea not infrequently glows with a phosphorescent light, and the wake of a vessel seems to be a trail of fire. This phenomenon, though confined to no particular part of the ocean, is most common in tropical waters.⁷

¹ The lime and silica are important, because they furnish materials for the shells of shell-fish and the skeletons of coral polyps.

² Near the tropics the ocean is saltier than in the vicinity of the equator, and its freshest waters are in the polar seas. The difference is due to the vast amount of rain that falls near the equator, and to the melting of the polar ice and snow. The saltness of the sea is greatest at the parallels 18° north and south latitude.

³ Analyses of sea-water from different parts of the ocean show the following results:

Red Sea.....	4.3 per cent.	Baffin Bay.....	3.3 per cent.
Mediterranean Sea.....	3.8 " "	Black Sea.....	1.9 " "
Atlantic Ocean.....	3.6 " "	Baltic Sea.....	0.6 " "
Pacific and Indian.....	3.5 " "	Gulf of Cronstadt.....	0.2 " "

⁴ Fresh water freezes at 32°, but sea-water, on account of the presence of mineral salts, has a freezing point varying from 28° to 32°.

⁵ The line of greatest warmth, or the oceanic equator, does not coincide with the geographical equator, but is deflected by the influence of currents and the proximity of land intensely heated. In the Atlantic the line of greatest heat is entirely north of the equator, its highest temperature of 89° being found in north latitude 28°. In the Indian Ocean the highest temperature is 87°, and occurs in the Arabian Sea; that of the Pacific is near New Guinea, and is about 89°.

⁶ Various Arctic explorers have believed that the temperature of the

ocean decreases towards the north to a certain limit, beyond which it increases, and that around the north pole there exists an iceless sea, more than 2000 miles in diameter. This view is not received by others, who maintain that the vast spaces of open water which are found in very high latitudes are caused by the action of winds and currents. In 1854 a wide expanse of open water was seen by Morton in 82° 30' north latitude. As far as the eye could see, no ice could be descried, the waves breaking at the foot of high precipices. In May, 1861, Dr. Hayes stood upon the shore of this sea, but it was then filled with broken ice. It has always been a favorite object with the Arctic explorers to find a route between Europe and Asia by the northern ocean. Unparalleled dangers and hardships have been encountered and endured to attain this object, and at length, after years of trial and disappointment, the Northwest passage was discovered by Captain McClure, in 1856; but the difficulties that beset it are so formidable that it can never be a pathway for commerce.

⁷ "While sailing," says Darwin, "a little south of the river La Plata, on one very dark night, the sea presented a wonderful and most beautiful spectacle. The vessel drove before her bows two billows of liquid phosphorus, and in her wake she was followed by a milky train. As far as the eye could reach, the crest of every wave was bright, the reflected light of which illumined the horizon." This phenomenon is caused by marine animalcula (*Noctiluca miliaris*), which have the power of emitting light, like the glow-worm or the fire-fly.



REVIEW AND MAP QUESTIONS ON SPRINGS, LAKES, RIVERS, AND OCEANS.

What is the subject of Part Fourth?
 Into what three principal systems are the waters of the globe divided?
 What are the subdivisions of the Land System?

SPRINGS.

Explain the origin of springs.
 What are dropping springs? Hot springs? Mineral springs?
 Name the different kinds of mineral springs.
 What is said of petroleum springs?

LAKES.

What is a lake?
 Name the great lake-systems of the globe.
 Trace on the map the lake-systems of Europe and Asia.
 Point out the lake-system of Africa, and describe it.
 Where are the lake-systems of the Western Continent situated?
 Describe each.
 What is said of the lakes of Eastern South America and Australia?
 What is the origin of salt lakes?

RIVERS.

What are rivers?
 What are the principal characteristics of rivers?
 What is said of the source of rivers? Their basins?

What are water-sheds?
 What is the effect of velocity?
 Describe the formation of a delta.
 Describe some of the more remarkable falls.
 What of the changes of level in rivers?
 Into what classes are rivers divided?
 Define oceanic rivers.
 What are the four systems of oceanic rivers?
 What are continental rivers?
 What are the chief continental systems?

OCEANS.

Describe the ocean.
 What are the divisions of the ocean?
 Give the boundaries of each ocean.
 What is said of the bed of the ocean?
 Describe the profile of the Atlantic Ocean (see Chart of Ocean-Currents, page 64).
 What is the Telegraphic Plateau?
 What is said of the depth of the ocean?
 What of its saltiness?
 What is said of the temperature of the ocean?
 What is said of the color of the ocean?
 What of its phosphorescence?

CHAPTER VI.

OCEANIC MOTIONS.

1. **The Ocean** is subject to three great movements—namely, *waves, tides, and currents.*

WAVES.

2. **Waves** are transient in their character, and are caused by the wind. They consist of the alternate rising and falling of successive ridges of water. The water appears to have a progressive motion; but this is an illusion: the wave is progressive, but ordinarily the water which constitutes it simply moves up and down.

Under the action of the wind, the top of the wave is pushed ahead, and, if the wind is very strong, it breaks into foam and forms "white caps" or "sead." In shallow water the lower part of the wave often drags on the bottom, while the top, advancing more rapidly, curls over and breaks. Such waves are called breakers, or combers.

The water and foam that break upon the shore constitute *surf*. Madras, in India, is noted for its surf; during heavy gales the rolling waves break in nine fathoms of water and at the distance of more than four miles from land.

3. **Size and Velocity of Waves.**—Waves vary with the strength of the wind. Under its continued pressure they increase in size; and on this account the largest waves are found in the open sea, where the sweep of the wind is unbroken.

The highest waves occur during heavy gales. At such times they rise to the height of forty feet above the general level of the ocean. Waves sixty feet high have been observed off the Cape of Good Hope; and on the route between Europe and America the masters of steamers have reported waves fifty or sixty feet in height.

In severe storms, when waves roll highest, the billows are not single, but consist of a series of waves accumulated upon one another. The upper waves are broken by the winds and driven forward in foam or dissipated in clouds of spray.

The breadth of a wave, its velocity, and the depth of the water in which it travels, have been found to have a mutual relation. A wave 100 feet broad and moving in water 100 feet deep has a velocity of about fifteen miles an hour; while another 10,000 feet broad and traversing the ocean at the depth of 10,000 feet advances at the rate of 154 miles an hour.

After a storm the ocean continues for some time to heave and roll in billows. The waves are propagated in some cases to the distance of 1000 miles beyond the area of the tempest which caused them, and the water is turbulent in regions where the atmosphere is perfectly calm. This motion is termed the *groundswell*.

4. **Earthquake-Waves.** These waves, incorrectly called "tidal waves," owe their origin to the disturbance of the ocean-bed by earthquakes. From the spot where the earthquake occurs, as a centre, vast waves radiate in every direction, higher and more terrific than those caused by the wind.

After the earthquake of Simoda, in Japan, the sea rolled in

upon the town in a wave thirty feet high, overwhelming it in an instant. Four or five similar waves followed at intervals, completing its destruction.¹

5. **The Force of Waves.**—The violence of waves is at times very great. During severe storms the force of the waves sometimes exceeds 6000 pounds on the square foot; ordinarily, it is about 600 pounds per square foot.²

TIDES.

6. **Tides** are the alternate rise and fall of the ocean twice in the course of a lunar day (twenty-four hours and fifty-one minutes). The water rises for about six hours, overflowing the shores and running into the channels of rivers: this is the *flood tide*. When the water has attained its highest elevation, *high tide* occurs.

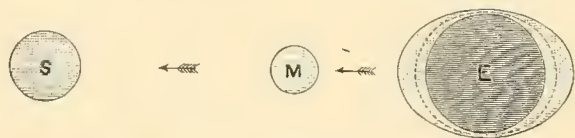
The water remains at this height for a few minutes, and then begins to fall, and continues to sink for about six hours. This is *ebb tide*. When the water is lowest it is *low tide*.

From this explanation it will be readily seen that there are daily two *high tides* and two *low tides*. The interval of time between two successive high or low tides is twelve hours and twenty-five minutes. Accordingly, when there is a high tide at any place, there must at the same time be also another high tide on the opposite side of the globe. The same is true with respect to low tides.

7. **Cause of the Tides.**—The *unequal* attraction of the moon and sun upon different parts of the globe produces the tides.

The mutual attraction of the moon and the earth causes the waters to be piled up at C, while their rotatory motion around each other tends to hurl the waters towards G, where they also are massed. An inspection of the accompanying figure shows that, by the action of the two forces, the water is drawn into the form of an oblate spheroid, in the centre of which is the earth. Thus, *two* tide-waves are formed—one on each side of the earth.

The sun, like the moon, produces tides in the ocean; but, on account of its great distance, the *inequality of attraction* upon the different parts of the globe is less than that of the moon, and it is the *inequality of attraction* that causes the phenomenon of tides. The lunar tide-wave is about five times as great as that of the sun.



SPRING TIDE—MOON IN CONJUNCTION.

8. **Spring and Neap Tides.**—The sun and moon produce tides independently of each other; but, as their relative positions are constantly changing during every month, their actions are sometimes united and sometimes opposed to each other. Twice a month—at new moon and at full moon—the sun and moon *act*

together, and the tides are then unusually high. These are the *spring tides*.

Twice every month the sun and moon *oppose* each other; for where the action of the former tends to elevate the waters, that of the latter depresses them. These are the *neap tides*. The relative heights of the spring and the neap tides are as seven to three.



NEAP TIDE—MOON IN OPPOSITION.

In the accompanying illustrations S represents the sun, M the moon, and E the solid portion of

the earth. The dotted line enclosing the earth is the boundary of the solar tide-wave; upon this is heaped the lunar tide-wave, bounded by the outer curved line.

From the foregoing explanation it will be seen that there are always two, and sometimes four, tide-waves in the ocean. Two of them are caused by the sun and two by the moon. The tide-waves of the sun, however, are so slight that they are not usually taken into consideration.

These waves follow the moon in its revolution around the earth, each wave performing its journey in about four weeks. But the earth, in the mean time, is turning upon its axis once in twenty-four hours; and therefore, instead of only two tides a month, there are two each day.³

9. **Direction of the Tide-Wave.**—While wind-waves disturb the sea to the depth of a few feet only, the tide-wave affects it from surface to bottom. If the globe were entirely covered by water, the movement and direction of the tide would be far less complicated. Then the tide-waves would follow the moon in her daily apparent revolution from east to west.

But the great masses of land are obstacles in the path of the tide-wave, and, as the latter cannot sweep across the continents, it must pass around them. Hence it is only in the broadest expanse of the Pacific Ocean that the tide-wave moves in the theoretical direction from east to west. In the North Atlantic Ocean the progress of the wave is northward; and the same is fairly true of the tide-waves of the Indian and North Pacific Oceans.⁴

Along western and northern coasts the direction of the wave is governed almost wholly by the shape of the coast-line. On the north coast of Norway it sets strongly towards the east.

10. **Cotidal Lines.**—The map on page 61 shows the approximate position of the crest of the tide-wave for each third hour of the day. Because of the continents and various shoal waters, the tide-waves, instead of moving with unbroken crests from east to west, are actually very irregular.

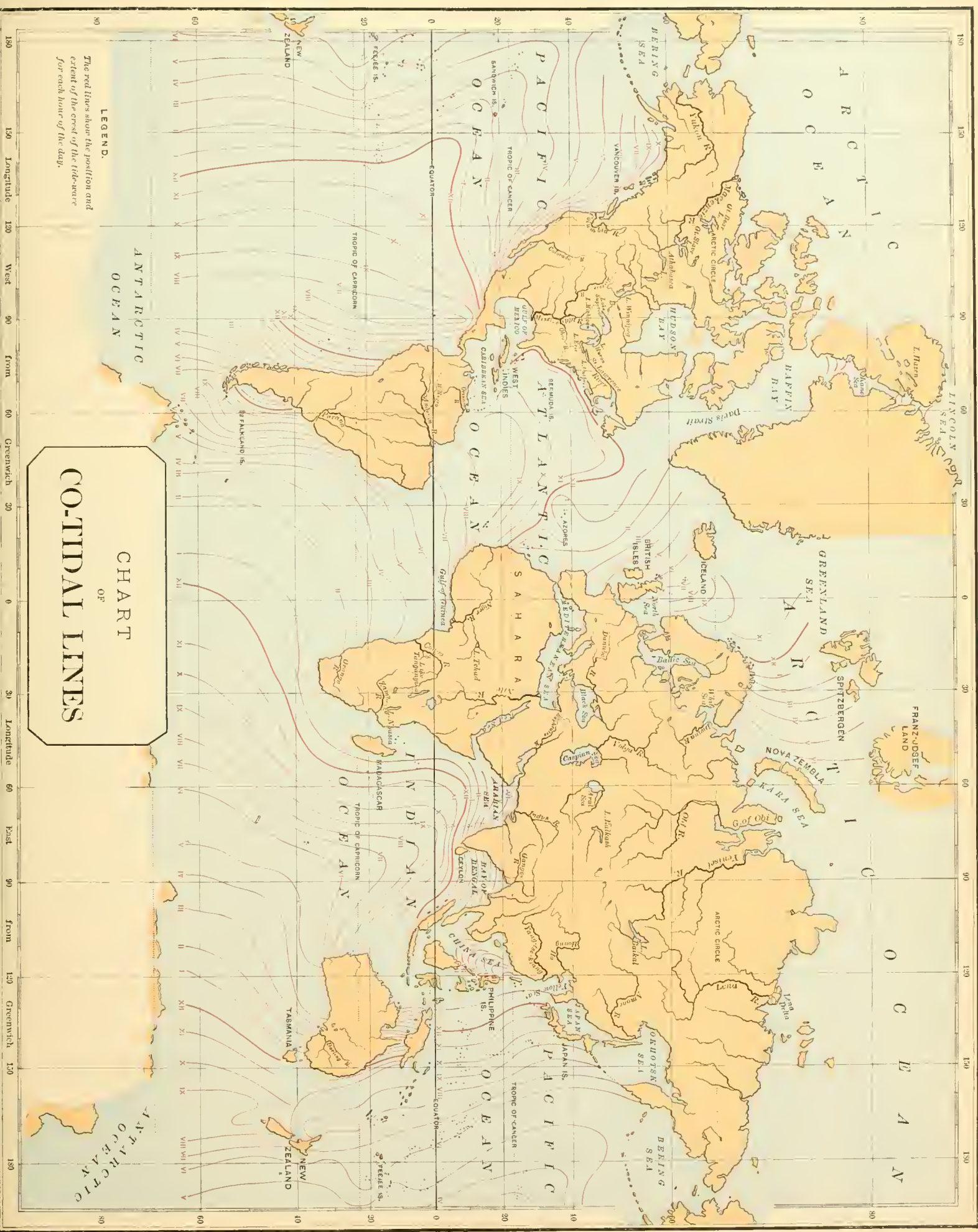
¹ The tide-gauges at San Francisco, California, which registered all the changes in the sea-level, showed that these earthquake-waves had travelled across the Pacific, a distance of 5000 miles, in twelve hours and twenty-eight minutes. At San Diego the waves arrived about an hour later than at San Francisco.

² In the Hebrides, a rock weighing forty-two tons was moved, in the height of a gale, several feet by the waves. Over the Eddystone Rock, in the English Channel, the sea breaks at times with tremendous violence. Three light-houses have been successively erected; the first two were

swept away by the sea. The present structure has withstood the force of the waves, although in severe storms they break over its top.

³ The earth rotates in the same direction as that of the tide-wave; but, while the earth makes a complete rotation, the tide-wave has also advanced in the same direction one twenty-eighth of a revolution. It will therefore require about fifty-one minutes more for a given point on the earth to overtake the crest of the tide-wave.

⁴ Lieutenant Greely found that the tide above Kane Sea came from the north. At Melville Bay it came from the south.



LEGEND.

The red lines show the position and extent of the crest of the tide-wave for each hour of the day.

CHART OF CO-TIDAL LINES

11. Time of the Tide.—If the waters of the ocean moved with perfect freedom, the tide-wave would keep directly under the moon, and would be highest at any place when the moon was on the meridian of that place. But the waters do not at once obey the action of the moon, because they are retarded by the friction against the bottom of the sea. It thus results that high tide does not occur at any place until several hours after the moon has crossed its meridian.

12. Height of the Tide.—On shores of islands in the midst of the great oceans the tides rise but little above the sea-level; and the average height for the islands of the Atlantic and Pacific is about three and a half feet. Along the coasts of continents the average altitude is from four to five feet.

But when the tide-wave rushes into a V-shaped bay, or through a narrow channel, it rises to a great height. Thus, at the entrance of the Bay of Fundy the rise of the tide is eighteen feet, and at its head it sometimes reaches the altitude of seventy feet. Within the English Channel the wave is so compressed that at St. Malo, on the coast of France, the height of the tide is fifty feet.

13. Derivative Tides.—The tides perceptible in rivers and in seas communicating with the ocean are called *derivative tides*. Derivative tides ascend large rivers to a great distance from their mouths; but their progress is so much retarded by friction against the land, and by other impediments, that several tides, in some instances, may be found at the same time in the same river.

When the tide enters suddenly the mouth of a river abounding with shoals, it checks the flow of the stream, and a high wave, called a *bore*, or *egre*, rushes up the river. In large rivers immense waves of this kind are formed.

In the Amazon, when the tides are highest, several waves, from twelve to fifteen feet high, simultaneously rush up the stream during several successive days.¹

OCEAN-CURRENTS.

14. Ocean-Currents are vast streams flowing through the sea, mingling the waters of different climes.

They move, for the most part, in a ceaseless circuit, returning to the regions whence they started. In some cases, a vast extent of ocean is embraced within their circuit; in others, the opposite branches of the current flow side by side; or one may traverse the deep sea, while the other flows above it.

15. Origin of Ocean-Currents.—It is now generally admitted that the heat of the sun is the chief cause of ocean-currents. It operates in various ways, all of which combined produce a complete system of the circulation of ocean waters.

i. The water of the ocean is not equally heated in all parts. In equatorial regions the surface temperature is about 80°, while in the polar zones it rarely exceeds 32°. The increase in temperature causes the waters of the tropical regions to increase in bulk and flow towards the poles.

ii. The rapid evaporation in tropical regions also removes a vast quantity of water; and, to supply the place of the water thus transferred, colder, and therefore heavier, waters flow from the polar regions.

¹ The bore of the Tsientung, in China, sweeps up the river as a wall of water thirty feet high, with a velocity of twenty-five miles per hour. The attractive force exerted upon the waters of a lake is so nearly the same in every part of it that the tide must be very slight. From observations made at Chicago, in 1859, it has been proved that Lake Michigan possesses a noticeable tide.

iii. The currents that set towards the equator from the poles as they reach lower latitudes pass into regions that have an increasing velocity. But the water cannot acquire this velocity at once; they therefore lag behind, forming apparently a westerly current.

iv. The current from the north polar regions, acquiring at the same time a westerly motion, becomes a southwest current; and that from the south polar zone, a northwest current. For similar reasons, the currents from equatorial latitudes acquire an easterly motion as they pass into polar regions.

The direction in which constant currents flow is identical with that of the prevailing winds of the region. The constant trade-winds drive the surface-water along, producing a current tending towards the southwest in the Northern Hemisphere, and towards the northwest in the Southern.²

These four currents—the two polar and the two equatorial—modified by their action on one another, by the configuration of the coasts upon which they strike, and by the form of the ocean-bed, give rise to the numerous streams that constitute the great circulating system of the ocean.

16. Arctic Current.—This current originates in the Arctic Ocean, and flows southward along the eastern coast of Greenland. It unites in about 50° north latitude with two other cold currents, coming down from the west coast of Greenland.

Advancing southward to Newfoundland, it sends off a branch into the Gulf of St. Lawrence, while the main current continues its course till it encounters the Gulf Stream in about 43° north latitude. Here it forms the counter-current of the latter, and probably flows as a submarine current.³ Numerous icebergs are borne down by the Arctic current. During May and June they are frequently met with in the route of steamers plying between New York and Liverpool.

17. The Atlantic Equatorial Current.—This current flows westward from Africa towards America. Near Cape St. Roque it separates into two branches, one of which flows southwesterly along the shores of Brazil, and the other northwesterly by the coast of Guiana into the Caribbean Sea. The length of this current, from Africa to the Caribbean Sea, is 4000 miles. Its average velocity is about ten miles a day.

The southwest branch, or the Brazilian Current, flows along the eastern coast of South America, and finally blends with the South Connecting Current.

The northern branch of the Equatorial Current skirts the coast of Guiana and enters the Caribbean Sea. Flowing through this sea, it passes between Florida and Cuba, and is thereafter known as the Gulf Stream.

18. Gulf Stream.—This is one of the most remarkable and important of all the ocean-currents, and has been more fully explored than any other. Its waters are of a dark indigo color, of so marked a hue that their line of junction with the ocean is distinctly traced by the eye.

The Gulf Stream flows along the coast of Florida with a velocity varying from two to five and a half miles an hour, reaching to the bottom and sweeping away the minute shell-fish that are strewn,

² According to Herschel and Carpenter, these streams owe their origin entirely to the action of winds.

³ The adverse current off the coast of North Carolina, known on the pilot charts as "Little Hell," is supposed to be caused by the rising of this current to the surface. It is marked by turbulent chop-seas, and after flowing about one hundred miles it disappears.

in places, along its course. Near Newfoundland it turns to the east, and, with diminished speed, spreads out like a fan towards the coast of Europe.

In latitude 50° it divides into two great branches. The northern branch forms an immense drift, which, pushed by the prevalent southwest winds, sweeps around the northern coast of Norway. The southern, driven by the northeast trades, returns to the equator, completing the circuit.

Within the area encircled by the southern branch of the Gulf Stream is the Sargasso, or *Grassy Sea*. Here the surface of the ocean is covered with sea-weed, in places so densely matted with marine plants that the water is concealed.

The maximum temperature of the Gulf Stream at the surface occurs off the coast of Florida. It is here sometimes as high as 86° . It retains its warmth far below the surface; for during winter its temperature off Cape Hatteras is about 57° at the depth of 3000 feet. From Cape Hatteras to the Grand Bank of Newfoundland the stream is warmer than the ocean by 20° or 30° .

After a course of 3000 miles, this stream still preserves a high temperature, forming a reservoir of heat, which, borne by south-westerly winds, considerably modifies the climate of Europe.¹



OFF THE NEWFOUNDLAND COAST.

19. North African and Guinea Current.—This current originates in the Atlantic, opposite France, and flows southward. Beyond the Strait of Gibraltar it follows the line of the African coast until it meets the Equatorial Current. Its velocity varies from twelve to fifty miles a day.

20. Antarctic Drift Current.—From the expanse of water around the south pole an immense drift of cold water sets towards the equator. This is the Antarctic Drift Current. Its general direction is towards the northeast. Its temperature is from 8° to 10° below that of the waters through which it passes.

The area over which the Antarctic Drift extends is one of prevailing westerly winds, which impart to it an easterly direction. It brings down icebergs from the south polar regions.

21. Equatorial Current of the Pacific.—This great current, 3500 miles broad, flows westward for a distance of 9000 miles from South America to the shores of Asia. Near the Indian Archipelago it divides into two branches, one of which sets southward along the coast of Australia, while the other

turns northward, and flows along the coast of Asia, under the various names of Japan Current, Kuro Siwo, and Black Stream.

22. Kuro Siwo.—This current in many respects resembles the Gulf Stream. Near the southern part of the island of Formosa it separates from the Equatorial Current, and flows northward along the southern shores of the island. Here its character is as decidedly marked as that of the Gulf Stream. In 26° north latitude it turns towards the east, flowing along the southeastern coast of Japan.

The Kuro Siwo is not only a much smaller current than the Gulf Stream, but it is also a colder one. The average surface temperature of its waters in winter is 63° , and in summer 70° . In winter, when the northwestern monsoons prevail, the Kuro Siwo does not flow farther north than latitude 39° , and sometimes its progress is checked for several days by adverse winds.

During the summer, however, when the prevailing winds blow from the southeast, the waters of this current flow as far northward as the Kooril Islands. It then obeys the same law that governs the Gulf Stream, and its drift, under the name of the North Pacific Current, is carried to the western shores of North America.

Recent surveys made by the U. S. Coast Survey show that no branch of the Kuro Siwo enters the Arctic Ocean through Bering Strait, as has been commonly supposed. On the contrary, the only current of this strait is a feeble one flowing from the Arctic Ocean.

23. North Pacific Drift Current.—This ocean-stream, the counter-current of the Pacific Equatorial, passes across the North Pacific, then, turning southward, skirts the shores of Northwestern America, and by its warmth softens the rigors of this clime. At length it bends to the west, and completes its immense circuit by merging into the Equatorial stream. A minor branch is sent off along the coast, called the California Current, which is prolonged from December to April by the Mexican Current, produced by the monsoon.

24. Periodical Currents.—These currents are caused chiefly by monsoons, or periodical winds that blow half the year in one direction and the other half in the opposite. Local causes, however, greatly modify their course. The principal currents of this kind are the Bengal and Red Sea and the East Australian and Mexican Currents in the Pacific.

The Bengal Current flows northeasterly along the eastern coast of India during summer, when the southwest monsoon prevails, and in the opposite direction in winter, the season of the northeast monsoon. Its velocity is greatest in winter, when it is about fifty miles a day.

The Red Sea currents flow north when south winds prevail, and south during the time of north winds. Hardly any current is perceived when the winds are changing and the atmosphere is but slightly disturbed. From May to October the waters of this sea are two feet lower at the northern than at the southern end—an effect due to the north winds, which then drive the waters of the sea into the Gulf of Aden. When the south winds prevail, the reverse is the case, the waters of the sea being higher at the northern end.

¹ It has been estimated that the amount of heat arising from the Gulf Stream on a winter's day is sufficient to raise the atmosphere over the British Isles from the freezing-point to a summer temperature. The Gulf

Stream is bounded on the shore-side by the cold counter-current, forming what has been termed the *cold wall*. Alternate bands of warm and cold water are occasionally found near and within the Gulf Stream.

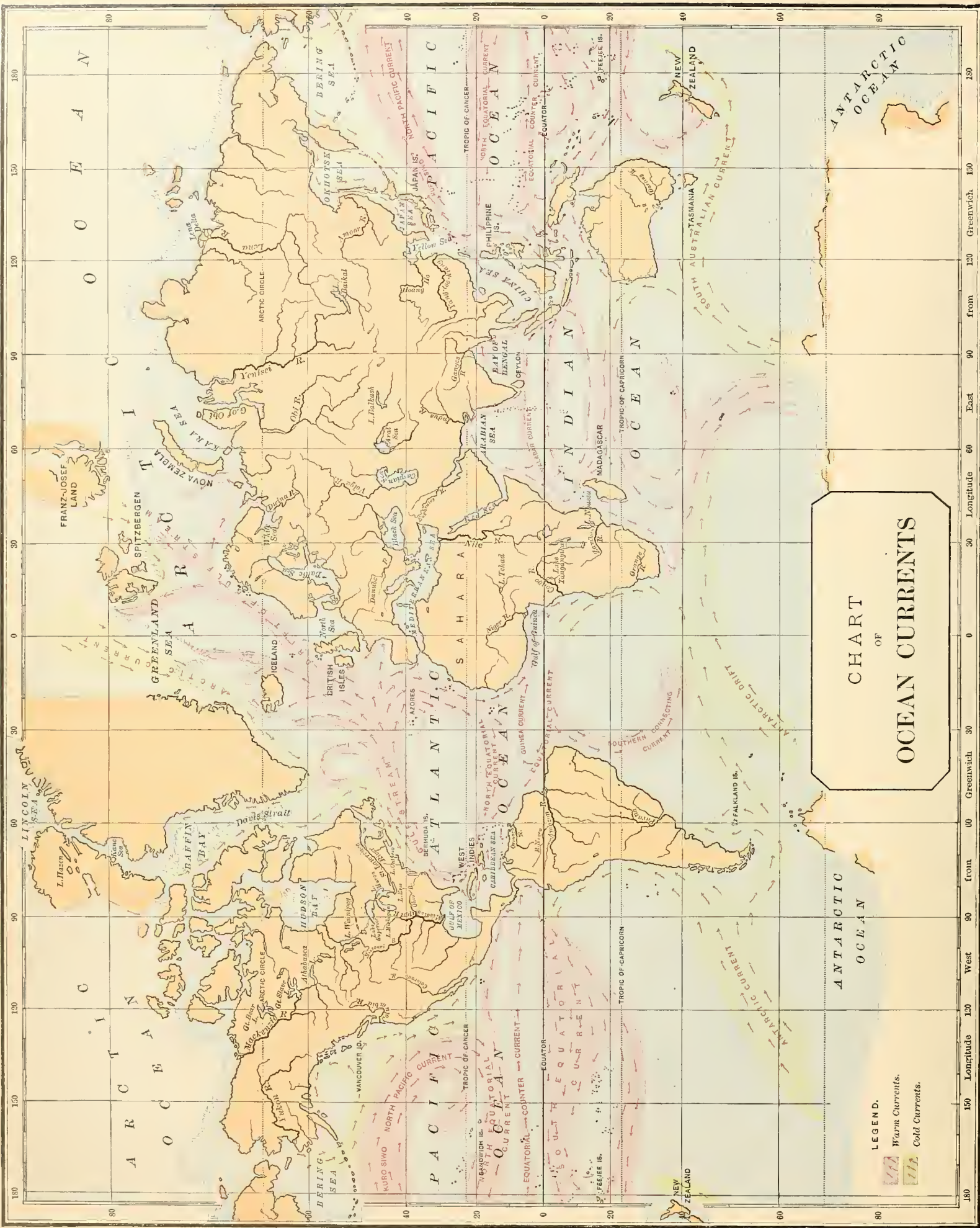


CHART
OF
OCEAN CURRENTS

LEGEND.
Warm Currents.
Cold Currents.

The Mexican Current, first described by Humboldt, is dependent on the monsoon. It flows southeast during the winter and northwest in the summer.

25. Local Currents.—Local currents are caused by the tides. They occur usually near deeply-indented coasts, where, from the configuration of the land, the water is driven through narrow channels. Such is the Roost of Sumburgh, south of the Shetland Islands, where the current at times exceeds fifteen miles an hour.

An even more dangerous current is that which rushes through the Hellgate, a narrow passage between New York City and Long Island. Through this channel the current is so swift and turbulent that none but steam-vessels can safely stem its flood.

Whenever the tidal current enters both ends of a channel, a whirlpool usually results from the conflict of waters. Such is the case of the celebrated Maelstrom, produced by the conflict of currents around the islands of Logödoën and Moskoë.

At high tide and at low tide the waters are comparatively quiet. But when the tidal-current is at full strength, during either the flood or the ebb, the Maelstrom becomes a dangerous passage. An

immense eddy is formed by the opposing currents, which is perilous to small craft.

At seasons of unusually high tides, when the wind is north-west, the whirlpool attains its greatest fury. It then becomes dangerous to even the most powerful vessels.

26. Submarine Currents.—Submarine currents have been discovered in various parts of the ocean. The great polar current that underlies the Gulf Stream has been better explored than any other, and its existence clearly proved by numerous thermometrical soundings, which have been made throughout its entire course.¹

27. Utility of Ocean-Currents.—Ocean-currents modify the extremes of climate, tempering the excessive heat of the equatorial regions and softening the rigorous climate of the higher latitudes. The sun heats the waters of the torrid zone to a temperature which would make the climate of the adjacent lands intolerable, if they were not borne away to distant regions and their place supplied by cooler streams. The warm waters give up their heat to the winds, and these in turn warm the regions over which they flow.

¹ The power of submarine currents is shown by the progress of icebergs, which often force their way against the wind and surface-current through the ice-fields of the polar seas. These stupendous masses float with eight-ninths of their mass below the surface, and the under-currents thus act upon them with greater power than the winds and upper currents. An officer connected with the Grinnell Expedition states that, on one occasion, while the vessels were endeavoring to advance northward against a strong surface-current setting south, an iceberg, with its top many feet above the

water, came drifting from the south, and passed them "like a shot." There is reason to believe, according to Lieutenant Maury, that these under-currents exist in nearly all parts of the deep sea; and a simple apparatus has been employed in the United States navy to detect their presence. A block of wood, so loaded that it sinks, is let down to the depth of from 600 to 2000 feet, and then sustained by a float. The float is then seen, where there is a submarine current, working its way against the wind and surface-current at the rate sometimes of more than a mile an hour.

REVIEW AND MAP QUESTIONS ON WAVES, TIDES, AND OCEAN-CURRENTS.

WAVES.

What are waves? Describe their nature. By what are they caused?
What is said of their size and velocity?
Describe earthquake-waves. How are they caused?
What do we know respecting the force of waves?
What causes waves to break?
What is meant by the ground-swell?

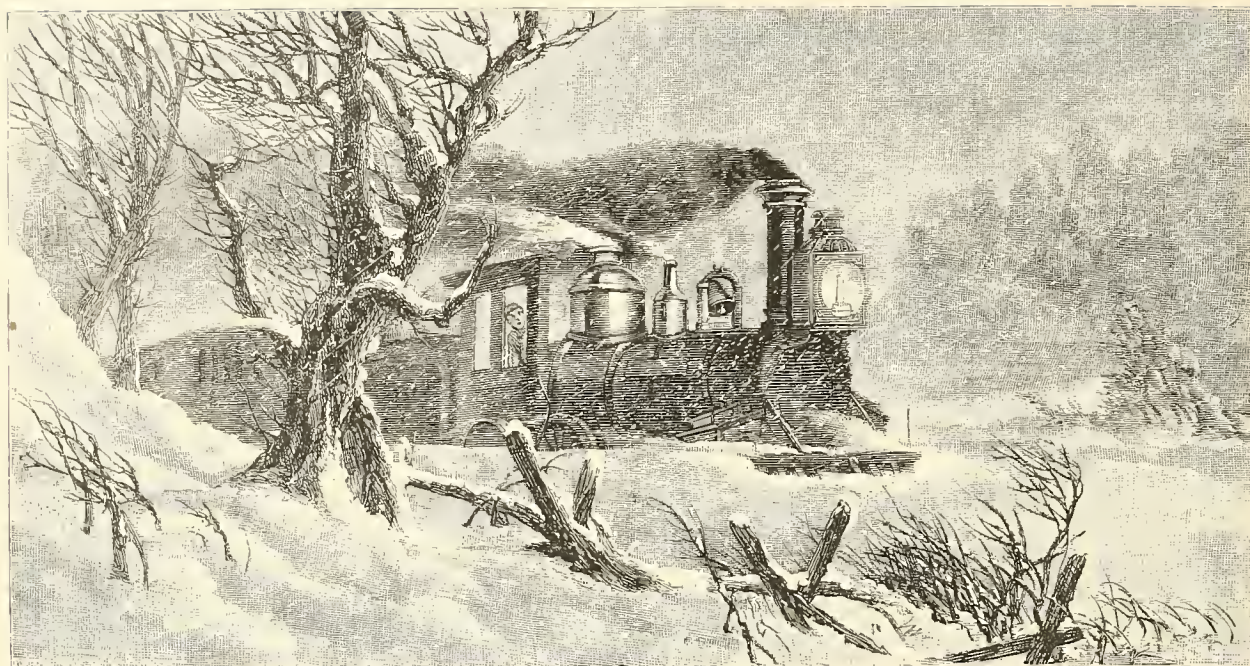
TIDES.

What are tides?
What is meant by high and low, flood and ebb tides?
What is the interval of time between two consecutive high or low tides?
How are tides caused? What are the spring and neap tides?
Draw a diagram showing the respective positions of sun, earth, and moon at spring tide. At neap tide.
Explain cotidal lines, and give reasons for their direction.
Give an account of the origin, progress, and velocity of the tide-wave.
Explain the cause of the high tides in the Bay of Fundy and similarly-shaped estuaries.
State what is said of the time and height of the tide.
What is said of the tides of lakes?
What is said with reference to tides in rivers?

OCEAN-CURRENTS.

How do ocean-currents originate? How are they classified?
Trace the courses of the great constant currents on the map.

How are the other currents caused?
Point out on the map the course of the Arctic Current.
Trace the Atlantic Equatorial Current from its origin. Where does it divide?
What branch skirts the eastern shore of South America?
Follow on the map the course of the Gulf Stream. What are its branches?
What is the Sargasso Sea?
What is said of the temperature of the Gulf Stream as compared with that of the surrounding ocean?
How is Europe affected by its warmth?
What currents flow by the western coast of Africa, and in what direction?
Describe the Antarctic Drift, and follow its course.
Describe the Pacific Equatorial Current.
What ocean-stream does the Kuro Siwo resemble?
Describe the North Pacific Drift.
How is Northwest America affected by it?
Point out and describe its branches.
What is the situation of the counter-current of the Indian Ocean?
Describe it. In what direction does it flow?
Point out on the map the periodical currents which are mentioned, and describe them.
How are local currents caused? Describe the Maelstrom.
What is said of the Hell Gate current in the East River?
What are submarine currents? Which of these is best known?
How is their existence proved by icebergs?



SNOW-STORM ON THE PRAIRIES.

PART FIVE.

METEOROLOGICAL PHENOMENA.

1. **Meteorology** is a description of the atmosphere and its phenomena. The atmosphere is a vast aerial ocean which envelops the earth. It is a constituent part of the earth, revolving with it, and partaking of its general motions.

CHAPTER I.

THE ATMOSPHERE.

2. **Constitution.**—The atmosphere is an invisible, elastic fluid. It is composed of two gases, *nitrogen* and *oxygen*, in the ratio of about seventy-nine parts of the former to twenty-one of the latter. With these is mingled a small quantity of carbon dioxide and other vapors. Aqueous vapor is always found in the atmosphere diffused amid its gaseous atoms, and increasing in quantity with the increase of temperature.

These gases, though differing in density, exist in a state of mixture, and intermingle so completely that they are found everywhere in substantially the same relative quantities.

3. **Weight, or Tension of the Atmosphere.**—The atmosphere rests upon the earth, exerting by its weight an average pressure, at the sea-level, of 14.7 pounds on each square inch of surface. This pressure, which is called the *tension* of the atmosphere, varies slightly with the latitude, being greatest at the 30th parallel.

¹ From the Greek words *barus*, weight, and *metron*, a measure.

² In general, a rising barometer indicates cooler weather; a falling barometer, however, is usually accompanied by rising temperature. When Glaisher and Coxwell ascended in a balloon, they rose so high that the barometer sank to ten inches, indicating an altitude of about five miles and three-quarters.

The tension of the atmosphere varies considerably with the height above the sea. At an altitude of three and one-half miles it is one-half, and at seven miles only one-fourth as great as at the sea-level.

The tension of the atmosphere is measured by ascertaining the height of a column of mercury contained in a glass tube, which is balanced by it. Such an instrument is called a barometer.¹

The barometer consists of a glass tube, about thirty-three inches long, closed at one end, and filled with mercury. The tube is kept in an inverted position, with the open end in a small vessel of mercury. At the level of the sea the column of mercury is about thirty inches high, but if the barometer be carried to a higher altitude the mercury will sink in the tube at the rate of one-tenth of an inch for every ninety feet of ascent.

The height of the mercury column varies considerably, even when the instrument is at rest. If the mercury rises in the tube, it indicates that more than the ordinary weight of air has accumulated overhead; if it falls, a decreased weight of air is indicated. A falling barometer is frequently accompanied by rain; a rising column, by winds.²

4. **Density.**—Because the atmosphere is elastic, a given volume will occupy less space under increased pressure, and the reverse. Therefore the lower strata of the atmosphere, which sustain the weight of the upper, are more dense than the latter, and the air is found to be more and more rarefied the higher we ascend.³

5. **Height.**—The height to which the atmosphere extends is not known. It is estimated at from fifty to five hundred miles. At the altitude of from forty to fifty miles above the earth it is sufficiently dense to reflect the solar rays. On the theory that

³ This rarefaction, at lofty altitudes, lessens the intensity of sound, produces lassitude, and renders respiration difficult; sight fails, and blood bursts from the veins. At Lake Sir-i-Kol, 15,600 feet above the sea, Lieutenant Wood found that a musket loaded with blank cartridge gave but a faint sound; a run of fifty yards made the runner gasp for breath, and it took hours of rest to restore his strength.

shooting stars are ignited by the compression of the air, the atmosphere must extend to the height of at least two hundred miles above the earth.

6. Temperature.—The atmosphere is warmed by the direct rays of the sun, and also by the heat radiated from the earth.¹ It is subject to variations in temperature, which arise from numerous causes, of which the principal are changes in latitude and in altitude.

The rays of the sun, striking the surface of the earth almost vertically within the tropics, give to that region more heat than to any other part of the globe. The temperature gradually decreases towards the poles, as the sunbeams fall at a less and less angle upon the earth's surface.

The temperature of the atmosphere decreases with the altitude. From the observations made by aeronauts, and by travellers who have scaled the highest mountains, the average loss of heat is about 1° for every 183 feet of elevation. In regions where the cold is intense, this law is partly reversed.

7. Mean Temperatures.—The *mean daily temperature* of any place is found by taking the average of the thermometrical observations made at stated hours during the day; and the *annual mean temperature* is the average of the daily mean temperature.

CHAPTER II.

WINDS.

1. Wind is air in motion. It is produced chiefly by changes in the temperature of the latter. When a body of air is heated, it becomes, bulk for bulk, lighter than the surrounding air. It therefore rises, and the colder and denser air flows in to fill the void that has been created.²

Changes of this kind are constantly occurring in all parts of the world. For, if two neighboring regions are unequally heated, an upper wind flows from the hotter to the cooler region, while the cold and heavy air of the latter produces a surface-wind flowing towards the warmer region. The difference in temperature between higher and lower latitudes thus produces a constant exchange of air.

The atmosphere, like the ocean, is ever in motion, and is traversed in all directions and at all heights by currents of air moving with varying velocity.

The velocity of surface-winds ranges from the slightest motion to the speed of the hurricane—more than one hundred miles an hour. The velocity of the upper currents is probably greater.³

The upper currents of the atmosphere move in directions contrary to those of the lower regions. This is shown by the drifting of volcanic ashes: during the eruption of Sumbawa, ashes were carried, by the sweep of the higher winds, eight hundred miles in a direction contrary to that of the surface-wind.

¹ Variations in temperature are measured by the thermometer—so called from the Greek words *thermos*, warm, and *metron*, a measure. In Fahrenheit's thermometer, the space between the freezing and the boiling-point is divided into 180 degrees, of which thirty-two extend below the freezing-point, to 0°, or zero. The freezing-point is, therefore, 32°, and the boiling-point 212°. For extreme temperatures the scale is graduated to 20°, 40°, and 60° below zero, the degrees being marked thus —20°, —40°, etc. Spirit thermometers are used at very low temperatures, as mercury freezes at about 40° below zero.

² This is proved by the simple experiment of Franklin. A door being

2. Winds Classified.—In regard to their duration, winds may be considered as *Constant*, *Periodical*, and *Variable*. The Trade-winds constitute, for the most part, the first class; the Monsoons and land- and sea-breezes, the second. Variable winds include those not comprised with other classes.

3. Trade-Winds.—Within the torrid zone a current of air sets towards the west, which maintains its rate and direction nearly unchanged throughout the year.

The atmosphere in the torrid zone, being intensely heated, expands and rises, flowing off in two upper currents towards either pole. To fill this vacuum, two cold surface-currents set in from the north and the south towards the equator.

If the atmosphere were influenced by no other cause, north winds would constantly blow towards the equator in the Northern Hemisphere, and south winds in the Southern. Their respective directions are, however, modified by the rotation of the earth, which imparts to them a westerly direction. The atmosphere moves easterly with the same speed of rotation as the solid globe. This speed is almost nothing near the poles, but increases as we advance towards the equator, where it is greatest.⁴

The lower current in the Northern Hemisphere is, therefore, influenced by two forces, one of which causes it to move from



THUNDER-STORM.

north to south, and the other from east to west, at the same time. The result of their combined action is a northeasterly wind. In the Southern Hemisphere the same forces give rise to a southeasterly wind.

In the Atlantic, the northeast trade-winds prevail between the 30th and 8th parallels of north latitude; the southeast trade-winds

opened that communicates between a warm and a cold room, the flame of a candle at the top of the door is bent towards the cold room, while at the bottom the direction of the flame is reversed, thus establishing a circuit.

³ The balloon of the aeronaut Elliot was carried thirty miles in twenty minutes.

⁴ The air in the Northern Hemisphere, moving towards the south, is constantly arriving at regions which have a greater easterly velocity than itself, and, in consequence of friction and of its own inertia, it does not at once gain this greater velocity, but lags behind, and acquires a relative westerly motion.



CHART OF WINDS

- LEGEND.
- Constant Winds.
 - Monsoons.
 - Region of Cyclones.

are comprised between latitude 3° north and 28° south. In the Pacific the belt of the trade-winds is situated a little farther to the southward.

The position of the trade-winds varies with the apparent course of the sun. Their limits move northward in summer and southward in winter. This vast current, sweeping over nearly the whole breadth of the torrid zone, advances westward around the globe at the rate of from ten to twenty miles an hour.

As the land is more intensely heated than the ocean, modifications in the direction of the trade-winds arise near the coasts of the continents. The air being more rarefied over the land than above the sea, the atmosphere moves landward, and the course of the trade-wind is in many instances thus deflected.¹

4. Zones of Calms.—As the northeast and southeast trade-winds approach each other their strength diminishes, being further weakened by the vast uprising column of hot air. The result is a zone of *calms*, or *variables*. Within this region the atmosphere is for the greater part in a dead repose, which is broken at intervals by furious cyclones and thunder-storms.

The belt of equatorial calms is north of the equator, and never moves south of it. The centre of the zone of equatorial calms in July and August is latitude 10° north; in March and April, about latitude 1° south. These limits thus annually shift their positions in latitude about eight hundred miles.

Near the tropics are two other calm-belts, termed respectively the Calms of Cancer and Capricorn. Their southern limits are near the two tropics, and their respective breadths are from 10° to 12° . These calm-belts are commonly known by the names of "Doldrums" and "Horse Latitudes."²

5. The Upper and Lower Westerly Winds.—The ascent of the heated air from the torrid zone gives rise to a constant upper wind, blowing in a direction contrary to that of the trade-winds. An upper southwesterly wind therefore prevails within the northern tropic, and a northwesterly wind within the southern tropic.

These upper winds, advancing beyond the tropics, become cooled, and, descending towards the earth, change in part to surface-winds. They are by no means so constant as the trade-winds, and at times give way to winds having an easterly direction. These winds are sometimes called *passage winds*.³

6. Monsoons.—On the southern and western coasts of the continents periodical winds prevail, termed monsoons. They blow for nearly six months in one direction; then follows an interval of calms, variable winds, and storms, after which they blow in a contrary direction for nearly the rest of the year. Terrific storms occur at the changing of the monsoons.

The northeast and southeast monsoons are thought to be portions of the trade-winds;⁴ the southwest and northwest monsoons are deflections of the same, caused by the proximity of heated regions during the summer.⁵

7. Land-and-Sea Breezes.—On the sea-coasts of the tropics a breeze sets in from the sea a few hours after sunrise. It steadily increases until the hottest part of the day, after



which it gradually dies away. Soon after sunset a breeze from the land arises, and blows seaward till morning, when it ceases, and the sea-breeze begins.

These breezes are most marked in the tropical latitudes, but they occur along the sea-coasts in nearly all latitudes. During the day, the land in the regions where they blow becomes warmer than the water; during the night it becomes cooler.⁶

The heated air becoming lighter ascends, and the cooler air of the ocean flows in to supply its place. As the sun sinks, the land loses its heat rapidly, and the air above it sinks in temperature until it is colder than the sea-air. When this occurs, the land-breeze commences.

This difference increases through the night, and with it the strength of the land-breeze. At sunrise, when the land-breeze blows strongest, this is greatest, the sea being from 15° to 20° warmer than the land. For the same reason, around extensive

¹ Near the continent of Africa the trade-winds are not felt within one hundred miles of the shore, and within this tract westerly winds prevail, owing to the great rarefaction of the air over the desert.

² The Calms of Cancer were termed the Horse Latitudes by seamen, from the fact that when cargoes of horses were formerly exported from New England to the West Indies, and ships were here becalmed, a part of the cargo was frequently thrown overboard to save water and fodder for the remaining animals.

³ In Western Europe the prevailing direction of the wind varies from 50° southwest to 88° southwest, while in the United States it is $87\frac{3}{4}^{\circ}$ west of south. The observations of such aeronauts as Green and Wise attest the existence of a constant upper westerly wind in the temperate climes of the Northern Hemisphere. The existence of northwesterly winds in the Southern Hemisphere is also abundantly proved both by the observation of Lieutenant Maury and by the record of the United States Exploring Expedition under command of Captain Wilkes.

⁴ This view is strenuously opposed by other authorities, who regard them as local deflections, which blow towards hot inland regions where there is a strong up-draught of heated air.

⁵ "The African monsoons of the Atlantic, those of the Gulf of Mexico, and the Central American monsoons of the Pacific, are for the most part formed of the northeast trade-winds which are turned back to restore the equilibrium which the overheated plains of Africa, Utah, Texas, and New Mexico have disturbed."—MAURY. Local causes, due to the configuration of the coast, modify the direction of these winds. Along the Mexican coast the northwest monsoon blows from November to April, and the southwest from May to October. The prevailing winds of the northwestern coast of North America have the nature of monsoons. This is especially noticeable on the Alaskan coast.

⁶ In the tropics, where the sea-breeze is most powerfully felt, the air over the land attains a temperature of 120° , while that over the sea seldom exceeds 80° .

lakes there is a breeze from the water in the morning and from the land during the night.

8. **Etesian Winds.**—These are periodical winds which for several weeks during the summer blow from the northeast over the Mediterranean and its adjacent countries. Throughout this season the African coast becomes intensely heated, while the waters of the Mediterranean possess a much lower temperature. A cool current of air sets in from a northern quarter, producing the winds in question.

9. **Northers.**¹—These are cold winds which blow over the plains of Mexico and Texas from October to March, seldom continuing for more than four or five days at a time. Their severity is greatest during the months of December and January.

10. **Variable Winds.**—Beyond the tropics the constant winds of the globe become feeble, and a variety of secondary influences check their flow and give rise to variable winds.

In the North Atlantic Ocean, the constant northeast polar and the southwest equatorial winds are thus in perpetual conflict, and variable winds prevail. In the Southern Hemisphere the prevalent winds are modified by the same influences, rendering them fickle and changeable, though in a less degree.²

The condition of winds with respect to temperature and moisture depends upon the direction whence they blow, and the nature of the surface over which they pass. Winds from the polar regions are cold and moist. Breezes from the equatorial regions, sweeping over the sea, are warm and moist; those over the land, hot and dry. Certain winds possess in these respects such marked peculiarities as to deserve particular notice.

The **Simoom** is an exceedingly hot wind which blows with the violence of a hurricane over the arid wastes of Asia and the Sahara of Africa. It is so dry that it quickly withers every form of vegetation with which it comes in contact. It has, however, none of the poisonous qualities which traditions have very commonly given to it.³

The **Khamsin** is a hot south wind peculiar to Egypt. It is most prevalent during the months of April and May, and seldom lasts more than three days at a time. It is similar to the simoom in its nature, but its effects are not so injurious.

The **Harmattan** is a periodical wind confined to the Guinea coast of Africa. It prevails from December to March. It is an extremely hot and dry wind; and during its prevalence a haze so dense obscures the sky that the sun is entirely hidden.

The **Sirocco** is a southeast wind which occurs during the summer in Italy and Sicily. It is most violent in the vicinity of Naples and Palermo. It comes from the desert over the Mediterranean, and is hot and humid and exceedingly oppressive.

The **Punas** are confined to the high table-lands of Peru. They are intensely cold winds, which descend from the icy

peaks of the Cordilleras. Being extremely dry, they so rapidly absorb moisture from animal tissue that the flesh of animals exposed to their influence quickly "cures," or dries.

The **Pamperos** are cold northwest winds which, rushing down from the snowy peaks of the Andes, sweep over the dry pampas of South America to the Atlantic. Clouds of dust are borne onward by these winds, and so great is their violence that a darkness like night sometimes prevails.

11. **Cyclones.**—Cyclones are rotatory or whirling storms, and are known by the various names of *hurricanes*, *typhoons*, and *tornadoes*. On the sea they originate usually near the limits of the trade-winds, but on land they are common on all large plains. The immediate cause of these storms is attributed to the overheating of the air next the earth.

The temperature of the atmosphere is not the same for all altitudes, but decreases, as already stated, at the rate of about 1° for every 183 feet of ascent. At times, however, when a calm rests over a large area, a thick stratum of air next the earth becomes greatly heated, and, bulk for bulk, is much lighter than the air overhead.

Such a condition is one of unstable equilibrium, and cannot last for any great length of time. Finally, at some point or other, the heated air forces a passage upward, and begins its ascent. The greater weight of the cold upper stratum now becomes apparent. It presses upon the warm surface-air, forcing it upward through the shaft thus formed.

The up-draught once started produces a wind at the surface of the earth which blows from all directions toward the ascending column. The latter gradually acquires a whirling motion, which does not cease until the warm air has risen and the cold air rests upon the earth.⁴

The cyclones of the Indian Ocean, the hurricanes of the West Indies, and the typhoons of the China Sea have their origin in this manner. But, while the ordinary whirlwind is only a few feet in diameter, the cyclone sometimes exceeds two or three hundred miles, and is, moreover, characterized by the most terrific violence.

The true beginning of the cyclone is the dead calm which precedes the storm, for it is during this time that the lower layer of air is becoming heated. When, at last, the up-rush of heated air begins, it is cooled slightly by its own expansion, and in an instant much of the moisture it contains is condensed and falls as a torrent of rain.

The latent heat from the condensed moisture at once gives the up-draught a violent impetus, and it quickly acquires a whirl of enormous velocity. So long as there is any condensation of moisture, so long will the cyclone continue its violence. As the storm advances its area increases, but the violence gradually

¹ The same name is applied to hot winds which are prevalent along the Pacific slope of North America during the fall and winter months. The "Santa Ana" and "Chinook" winds are of the same character.

² According to Professor Coffin, three systems or circuits of winds prevail in each hemisphere between the equator and the poles. Thus, approximately, in the Northern Hemisphere the first is found between the equator and latitude 30°; the second reaches from latitude 30° to latitude 60°; and the third, or polar, extends from latitude 60° to latitude 90°. In all these systems in the Northern Hemisphere, except in the second, the upper winds are southwesterly and the lower northeasterly. At the limits of these systems calms are supposed to occur like those of Capricorn and Cancer.

³ "It comes like the heated air from a fiery furnace, producing fainting and lassitude, and soon, increasing in violence, raises the sand in clouds, penetrating the eyes, nose, and mouth. The camels are arranged in line,

and beside them the travellers prostrate themselves for shelter. Soon the flying sand drifts as high as the camels' backs, and a new line must be formed, amid the thick darkness produced by the hot and blinding sand. Again and again must this be done, and frequently in vain. A caravan of twenty thousand pilgrims, returning from Mecca, were once overtaken by the simoom, and only eighteen escaped to tell the tale."—BUCKINGHAM.

⁴ The sand-whirls so frequently seen in the Colorado and Mojave Deserts are fine illustrations of the manner in which whirling storms originate. On almost any morning in the spring-time one may see slender columns of fine dust rising to the height of a thousand feet or more. These columns of dust mark the up-draughts of air, and they usually exhibit a vigorous whirl. After nine or ten o'clock in the morning a light breeze begins which mixes the warm air with the cold, and prevents the further formation of the whirls.

decreases until it has travelled well into temperate latitudes, where it finally ceases.

Usually, a storm of this character is confined to the ocean. Occasionally, however, it sweeps along the coast of a continent. In most instances it is dissipated in mid-ocean, but sometimes it travels across the ocean, and does not cease until it has reached far into the interior of a continent.

12. Origin and Direction.—Cyclones originate most frequently in the equatorial calm-belt. They seldom occur within

eight or ten degrees of the equator, and they never cross it. The path of the cyclone corresponds with the direction of the prevailing winds, being westerly in equatorial and easterly in temperate latitudes, as shown in the accompanying diagram.¹

Within the Northern Hemisphere the whirl of the cyclone is in a direction contrary to the motion of the hands of a clock; within the Southern Hemisphere the storm whirls in the same direction as the clock-hands move.

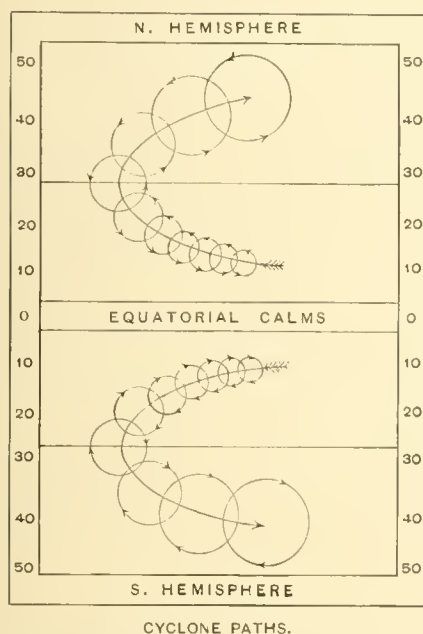
The tracks of the Gulf Stream and the Kuro Siwo are the regions most frequently visited by cyclones. They are also prevalent in the warm currents of the Indian Ocean and east of Australia.

13. Storm-Cards.—By a knowledge of the laws which govern the motion and direction of cyclones, the master of a vessel is able not only to avoid a cyclone but also to steer his way out of the storm if he should be overtaken by one. The law is invariable: Facing the wind, the centre of the storm is on the right hand in the Northern Hemisphere and on the left hand in the Southern Hemisphere.

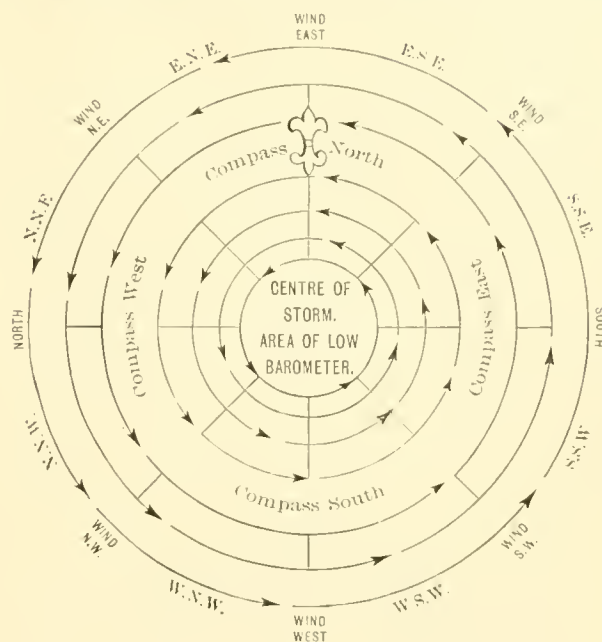
In many cases vessels are provided with storm-cards similar to those in the accompanying cut. The master of the vessel places the card belonging to the proper hemisphere on the chart in the latitude and longitude of his vessel, and with the wind's place over the ship's position. He may then determine at a glance not only the position of the centre of the storm, but also the direction in which it is moving.²

14. Tornadoes.—Tornadoes are whirlwinds confined to the

land. The whirl is seldom more than half a mile in diameter, and the storm does not usually travel more than ten or fifteen

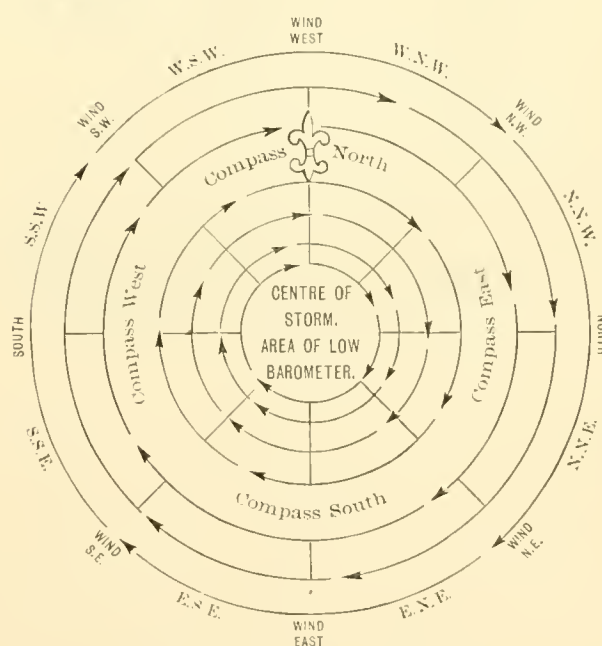


CYCLONE PATHS.



STORM-CARD, NORTHERN HEMISPHERE.

miles. In destructive effects, however, the tornado equals, if it does not surpass, the cyclone.



STORM-CARD, SOUTHERN HEMISPHERE.

¹ The cyclone does not come without warning. Every thorough sailor knows the localities in which he may expect to encounter cyclones, and acts accordingly. A sultry, murky atmosphere, and a few streamers of cat-tail clouds, are usually the first signs. A falling barometer and a veering wind will leave no doubt of the approach of the storm. Soon a dense bank of clouds appears above the horizon. This is the edge of the storm, which is advancing at a rapid rate. The prudent mariner has prepared for it, however, and rides only in its outer limits, with all canvas save the storm-sail closely reefed.

² Thus, in the Northern Hemisphere, within the tropics, if the wind is northeast, the centre of the hurricane lies to the southeast of the ship, and the body of the storm is moving to the northwest. The mariner, therefore,

will bear away to the southwest and escape the storm: a course east of south would bring him into the heart of it. In the Southern Hemisphere, beyond the tropics, a northwest wind shows that the centre of the storm lies to the southwest of the ship, and, as the storm is moving to the southeast, the course which insured safety in the former case would bring destruction in this. The cards and the accompanying figure represent the tracks and the direction of rotation of cyclones in the Northern and Southern Hemispheres. By supposing the centres of the storm-cards to be placed upon these tracks, and to be moved along them in the direction in which the cyclone advances, with the compass pointing north, the preceding statements will be readily understood, and the use of the storm-cards clearly seen.

At the centre of the storm the whirl is so rapid that a vacuum is formed. This vacuum is the "funnel-cloud" of the tornado. Wherever it touches destruction follows. Large trees are "twisted into ropes," or else uprooted, and buildings burst to pieces with explosive violence.¹

The rotatory motion of the tornado is shown by the spiral or circular lines over which the débris is scattered. Like other whirling storms, it is preceded by sultry weather, and usually by a falling barometer. It is always accompanied by rain or by hail.

The direction in which the tornado travels is in accordance with the law of storms. In the United States its path is generally to the east or to the northeast.

Tornadoes are very prevalent in the Mississippi Valley, especially in the central and northern parts. They are most frequent during the summer season, but occasionally they occur early in the spring and late in the fall months.²

15. Waterspouts.—From the foregoing principles of whirling storms it may be inferred that when the vacuous centre, or "eye" of the rotatory storm passes over a body of water, the



WATERSPOUTS.

latter will be drawn into the vacuum. Such is the case, and the tornado of the sea is usually a waterspout. The lower part of the waterspout is generally a mass of water, but as it ascends the water is soon whirled into a fine spray, and then vaporized.

16. Ordinary Storms.—Many of the ordinary storms partake of the nature of cyclones. They consist of a central area of low barometer, towards which the wind is blowing with a rotatory motion. Since the establishment of the United States

¹ The velocity of the wind in a tornado probably exceeds one hundred and twenty-five miles per hour, and this, together with its whirling motion, accounts in part for its destructive effect. There is another and an equally powerful factor—namely, the difference in atmospheric pressure. This is noticeable when the "funnel-cloud" strikes a building. Within the building the atmospheric pressure is fourteen or fifteen pounds per square inch; in the vacuous funnel-cloud it is, at most, but two or three pounds. Therefore, when the storm centre encloses the house, the latter flies to pieces outwardly as quickly as though a charge of dynamite had been exploded within it, and the débris is drawn up into the vortex of whirling air.

² A destructive tornado swept over St. Cloud and Sank City, Minnesota, in the spring of 1886. A large part of Sank City was laid in ruins, and St. Cloud was almost as badly damaged. More than one hundred people

Weather Bureau, it has been learned that these storms are governed by the laws which control cyclones, from which they do not differ, except in violence.

17. Storm-Tracks.—There are three storm-tracks within the United States which are fairly defined, and to which most of the ordinary storms confine themselves.

I. The storms of the Atlantic coast originate usually in the Gulf of Mexico, or in the Caribbean Sea. They follow the trend of the coast, seldom extending more than three or four hundred miles inland. Their course is towards the northeast.

II. The storms of the Mississippi Valley begin in the north-western part of the valley, and, after veering a few degrees southward, take a northeastward course across the continent.

III. The storms of the Pacific coast commonly travel in a southeasterly direction, reaching no farther west than the crest of the Cascade and Sierra Nevada Mountains. An occasional storm, originating in the Pacific, strikes the western coast, and, instead of turning southward, crosses the Western highlands and makes its way towards the Atlantic Ocean.

18. Storm Predictions.—A storm having once started, it is not difficult either to predict its course or to estimate its rate of travel. Practically these are known beforehand, and it is only when a storm is dissipated, or turns out of the usual course, that the prediction fails.

With telegraph stations and trained observers scattered over the United States, all slight deviations in the course and direction of the storm can be readily noted.³ The area of low barometer is the centre of the storm, and the latter travels in well-known paths.

19. Navigation.—An accurate knowledge of the phenomena of winds, ocean-currents, and tides is of great importance to the world, by facilitating the operations of commerce and increasing its security.

At no other period has this knowledge been so imperatively demanded as within the present century; for during this time commerce has been rapidly developed, and its energy and enterprise have been aroused to full activity by the inventions of science and the discovery of new fields of industry.

From the numerous log-books of the commercial and naval marine Lieutenant Maury constructed a series of wind and current charts, accompanied with sailing-directions, which are of great service to mariners, and new routes have been discovered by which the voyages of vessels have been much shortened.

Voyages from the United States to Australia have been reduced from 127 to 92 days, and between England and Australia from 111 to 90 days. Formerly the average passage from New York to California was 180 days. Now it is less than 130 days. Voyages have even been made in 92, 91, and 89½ days.

lost their lives in this catastrophe. Within the past fifty years between six hundred and seven hundred tornadoes have occurred in the Mississippi Valley, and more than one thousand lives have been lost.

³ Under the direction of the United States Weather Bureau, observations are taken simultaneously at about two hundred and fifty stations, situated in different parts of the United States. These observations include the temperature, the height of the barometer, the relative moisture, the direction and force of the wind, and the amount of rain-fall at each station. They are taken three times a day and telegraphed to the central office of the Weather Bureau at Washington, D.C., and the results are immediately entered upon the weather map for that day. With these data the chief observer is enabled to make the predictions, or "probabilities," for the following day. The predictions of local storms are more apt to fail than those of general atmospheric disturbances.

CHAPTER III.

AQUEOUS PHENOMENA.

1. **Dew-Point.**—The moisture that rises from the sea and from the land is diffused throughout the atmosphere in an invisible state. An increase of temperature greatly increases its capacity for moisture; a decrease of temperature lessens it.

It has been found that if the temperature of the air is increased or decreased, its capacity is augmented or lessened in a geometrical ratio. If the air contains all the moisture it can hold at a given temperature, it is said to be *saturated*, or at the *dew-point*.¹

In the following table is shown the weight of aqueous vapor in grains that a cubic foot of air will contain at various temperatures when saturated. An inspection of the table shows that the moisture-holding capacity increases at a much greater rate at high than at low temperatures:

TEMPERATURE.	WEIGHT OF VAPOR	TEMPERATURE.	WEIGHT OF VAPOR.
0°	0.6	85°	12.8
10°	0.8	90°	14.8
20°	1.3	92°	15.7
32°	2.1	94°	16.5
40°	2.9	96°	17.7
50°	4.1	98°	18.7
55°	4.9	100°	19.8
60°	5.8	101°	20.4
65°	6.8	102°	20.9
70°	8.0	103°	21.5
75°	9.4	104°	22.6
80°	11.0	105°	22.8

RAIN.

2. When bodies of warm air and cold air mingle, they are unable to retain the same amount of moisture that they can separately hold, because their capacity diminishes faster than their temperature. If the difference of their temperatures is considerable, a part of the vapor gathers into drops and descends as rain.

3. **Causes of Precipitation.**—Thus, rain is caused by cold blasts sweeping down from the mountains into the warm valleys, by warm winds being driven up the slopes of the mountains, and by the conflict of great aerial currents, which, differing in temperature, are constantly traversing the atmosphere in all directions, bringing rain to almost every part of the globe.

1. Thus, an ascending current of air is cooled by its own expansion, and, because it is cooled, it cannot hold so much of its

¹ The moisture of the atmosphere is measured by the hygrometer, an instrument consisting of two thermometers, the bulb of one being covered with muslin. In making an observation the covered bulb is moistened with water, which, in evaporating, cools the bulb and lowers the temperature. The percentage of moisture is calculated from the difference in the reading of the thermometers.

² The equatorial rain-belt is a zone of almost perpetually falling rain. It is situated between the northern and southern trade-winds, and oscillates from north to south with them. It never passes south of the equator.

³ In the south temperate zone the rain-fall is somewhat less, being about thirty-three inches.

⁴ Thus, at Bergen, in Norway, the warm and moist southwestern winds, checked by the Kiölen Mountains, produce an annual rain-fall of eighty-eight inches, but on the Baltic side only twenty-one inches fall in a year. At Rio Janeiro, in Brazil, the annual rain-fall is fifty-eight inches; while in the same latitude on the western coast stretches the almost rainless district of Pern.

⁵ The mean annual fall of rain on the western side of England is 50 inches, and on the eastern 27.4. In Ireland the westerly rain-fall is 47.4, and the eastern 29.7. The moist southwestern winds give rise to this phe-

nomenon in Europe; and the same cause is assigned for the excess of rain on the coast of Oregon. Because the temperature of the air decreases with its altitude, its capacity for moisture also decreases; there must, consequently, be less vapor in the atmosphere the higher we ascend, and therefore less rain. This is true in respect even to moderate elevations. The annual fall of rain on the roof of York Minster was found to be several inches less than that on the ground, 213 feet below. In the United States the same fact is observed in the Pacific region; for while on the coast the annual quantity of rain rises as high as 65 inches, it ranges on the Rocky Mountain plateau only from 3 to 15 inches. Where, however, the warm winds of the plains, charged with vapor, drive up the cool slopes of lofty mountains, the amount of rain increases with the altitude up to a certain point, beyond which it decreases. The peninsula of India presents more striking examples of this fact. The Ghauts Mountains, running parallel to the coast, arrest the moist southwest monsoon, and cause a vast precipitation of rain on the Malabar shores. At Trivandrum, India, 130 feet above the sea, the annual rain-fall is 64 inches, while at Mahableshwur, which is in 17° 56' north latitude, and 4500 feet above the sea, it is 254 inches. But all this is exceeded by the amount which pours down at Cherrapong, an elevated station in the Himalayas, where 610 inches of rain fall yearly.

ii. When moist warm winds are driven up the slopes of lofty mountain ranges, a copious condensation of moisture takes place. The excessive rain-fall on the northwestern coast of North America illustrates this law.

iii. The intrusion of warm currents of air into high latitudes, where they are cooled below the dew-point, is another cause of rain. Examples of this are seen in the monsoons which are prevalent on certain southern and western coasts.

4. **Distribution of Rain.** For the reasons already given, it is clear that the higher the mean temperature of any region, the greater is its rain-fall. We should therefore expect to find that the annual rain-fall at the sea-level decreases from the equator to the poles; and this, as a general rule, is the case, as is shown by the accompanying table:

Paramaribo, Guiana.....	5° 40' N. Lat.	229 inches.
Sierra Leone.....	8° 30' "	189 "
Grenada (Little Antilles).....	12° 15' "	193 "
Macao.....	22° 11' "	68 "
Savannah, Ga.....	32° 05' "	49 "
London.....	51° 31' "	25 "
Upsal.....	59° 54' "	16 "
Uleaborg.....	65° 01' "	13.5 "
Maranham.....	2° 31' S. Lat.	280 "

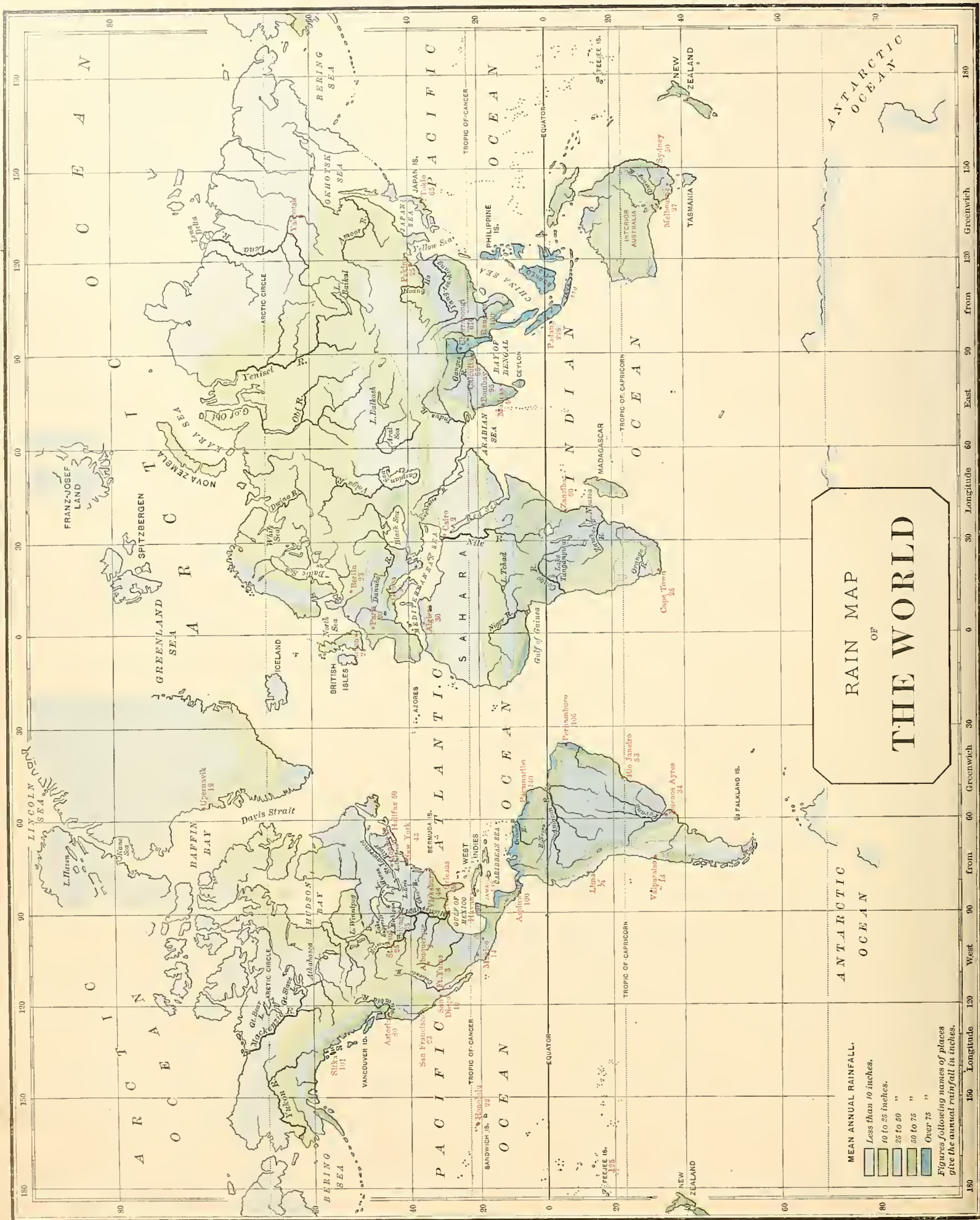
In the torrid zone the yearly rain-fall is ninety-six inches. In the north temperate zone³ it is only thirty-seven inches. In the frigid zone it is much less. This law is, however, subject to many exceptions, arising from various local influences, such as the configuration of the land and the prevalence of winds.⁴

The air over the sea is always more humid than that above the land, and on this account the rain-fall decreases from the coast to the interior of a continent. Thus, in the United States, while the annual rain-fall on the coasts ranges from forty to seventy-two inches, it sinks as low as ten inches in parts of the Great Central Plain.

In Europe, likewise, the same law obtains. The rain-fall on the western coast varies from thirty to one hundred and eleven inches, while in Central and Eastern Europe it is about fifteen inches.

More rain descends upon the southern and western coasts of continents than upon the eastern, so far as observations have been made. In the United States the annual rain-fall on the eastern coast is forty-two inches, while between the same parallels on the western coast it ranges from forty-five to sixty-five inches.⁵

nomenon in Europe; and the same cause is assigned for the excess of rain on the coast of Oregon. Because the temperature of the air decreases with its altitude, its capacity for moisture also decreases; there must, consequently, be less vapor in the atmosphere the higher we ascend, and therefore less rain. This is true in respect even to moderate elevations. The annual fall of rain on the roof of York Minster was found to be several inches less than that on the ground, 213 feet below. In the United States the same fact is observed in the Pacific region; for while on the coast the annual quantity of rain rises as high as 65 inches, it ranges on the Rocky Mountain plateau only from 3 to 15 inches. Where, however, the warm winds of the plains, charged with vapor, drive up the cool slopes of lofty mountains, the amount of rain increases with the altitude up to a certain point, beyond which it decreases. The peninsula of India presents more striking examples of this fact. The Ghauts Mountains, running parallel to the coast, arrest the moist southwest monsoon, and cause a vast precipitation of rain on the Malabar shores. At Trivandrum, India, 130 feet above the sea, the annual rain-fall is 64 inches, while at Mahableshwur, which is in 17° 56' north latitude, and 4500 feet above the sea, it is 254 inches. But all this is exceeded by the amount which pours down at Cherrapong, an elevated station in the Himalayas, where 610 inches of rain fall yearly.



5. Rains within the Tropics.—Within the torrid zone the year is divided into two seasons—the wet and the dry. For a period varying from three to five months rain falls in great quantities, while during the remainder of the year scarcely any



RAINY SEASON—BEGINNING OF THE MONSOON

occurs. In the Northern Hemisphere the rainy season begins in April and extends to October. In the Southern Hemisphere the periods are reversed, the rainy season lasting from October to April, and the dry from April to October.¹

6. Rains beyond the Tropics.—In temperate regions, where the currents of air are constantly changing, the rains are distributed throughout the year with great irregularity.² Western coasts, however, are an exception to this law. Here the rain falls during the winter months, little or none falling in summer.

7. Rainless Districts.—Stretching in an immense belt across the Eastern Continent is a vast tract, comprising regions upon which little or no rain ever falls, and others where it descends only in minute quantities.

This belt begins in Africa, at Morocco, and stretches eastward over the Sahara, Egypt, Arabia, and Persia, to the base of the Himalaya Mountains. Beyond these it is continued in the vast Desert of Gobi and the table-land of Thibet.³

In the Western Continent the rainless tracts embrace the Great Interior Basin, the table-land of Mexico, a portion of Guatemala, and a strip of land that skirts the base of the Andes for a distance of 1500 miles.

The absence of rain in these localities is explained in different ways, according to the peculiarities of their several situations.

¹ The rainy season commences with storms of the most terrific nature, especially in the peninsulas of India. "Its approach is generally announced by vast masses of clouds that rise from the Indian Ocean and advance towards the northeast, gathering and thickening as they come to land. In a few days the southwest monsoon sets in, attended by thunderstorms far exceeding in intensity those of the temperate climes. Soon the rain descends in torrents, swelling the rivers and deluging the plains; and the earth, which before was parched and dry, is quickly clothed with luxuriant verdure."—ELPHINSTONE.

² In Germany twice as much rain falls in summer as in winter; while in the west of England the winter rains are eight times greater than those of summer. In the countries of Southern Europe the winter rains are in excess, but in those of Western Europe the autumnal rains predominate.

The intense heat of the Sahara increases its capacity for moisture, so that the vapor borne from the sea retains its invisible state, and there are here no cool mountain-heights whereby it may be condensed.

South of Egypt, the moisture borne by the north winds up the Abyssinian ranges descends in floods, which cause the inundation of the Nile. To this Egypt owes its amazing fertility, for it is a country where rain scarcely ever falls.

In the great Desert of Gobi the northerly land-winds are dry, while towards the south the high ranges of the Himalayas intercept the moisture borne by the southern winds. To a like cause is attributed the existence of the rainless regions of the Western Continent. The humid southeast trade-wind, sweeping across the plains and pampas, loses nearly all its humidity before it passes these lofty mountains, and the regions east of them are consequently destitute of rain.

8. Regions of Almost Constant Rain.—Near the equator, in the zone of variable winds, light and changing breezes are perpetually alternating with calms, and rains are almost constantly occurring. In the low plains of Guiana, swept by the moist trade-winds, rain falls for five or six months almost without intermission.

9. The Annual Rain-Fall of the Globe.—The annual fall of rain in the torrid zone is estimated at 8.5 feet; in the temperate zone, 3.05; and in the frigid zone, 1.25—an amount which, taking into account the surfaces of the respective zones, would cover the earth to the depth of about five feet.

FOGS AND MISTS.

10. Fogs and Mists are visible vapors that float near the surface of the earth. When a body of cool air mingles with one that is warmer and humid, and which differs from it but slightly in temperature, the moisture is partly precipitated in the form of fogs and mists.⁴

11. Distribution.—In the polar regions dense fogs prevail throughout the year. In the summer the air over the land becomes warmer than that over the sea, and heavy fogs arise from their union. In the winter the case is reversed: the sea is warmer than the land; but the result is the same.

In the North Atlantic Ocean, where the winds warmed by the Gulf Stream meet the cold polar currents, a part of the moisture is precipitated, and dense fogs occur. It is for this reason that fogs prevail to such an extent on the Banks of Newfoundland; and for a similar reason they also shroud the Aleutian Isles.

Fogs during the nights of summer gather over moist valleys, and along the banks of rivers. The land radiates heat more rapidly than water, and, losing its warmth, the air in turn is also cooled, thereby giving up a part of its moisture and causing fogs to form.

³ These districts are not absolutely without rain, but the precipitation rarely exceeds more than one or two inches a year. Whenever a rain-storm occurs it is usually violent, but of short duration.

⁴ In rain the condensed vapor gathers into drops, but fogs consist of countless numbers of minute globules, which float in the air. This stage, which is a form intermediate between a liquid and a vapor, is called its "critical" stage. The mist which in a hot summer day hovers about an ice-cart illustrates the formation of fog. The moisture precipitated from the atmosphere sometimes descends at once as rain, without passing through the intermediate state of cloud. In 1852 a brisk shower fell at Washington, D.C., for the space of several minutes, from a perfectly cloudless and starlit sky. Many similar instances have been observed. The phenomenon is not infrequent in tropical countries.

CLOUDS.

12. **Clouds** are fogs floating in the higher regions of the atmosphere. Usually they are formed by the uprising of warm currents of air from the heated surface of the earth.

These currents becoming cooled as they ascend, their capacity for moisture constantly diminishes, until at last they cannot retain all they possess, and the excess becomes visible as a cloud. If the column of air is borne higher, the cloud increases; if it sinks towards the earth, the vapor is absorbed and the cloud disappears.

13. **Height of Clouds.**—Clouds range in height from a few feet to several miles. Gay-Lussac ascended in a balloon to the altitude of 23,000 feet, and at that elevation beheld clouds floating far above him.¹

14. **Classification of Clouds.**—Clouds are distinguished by their forms as *Cirrus*, *Cumulus*, *Stratus*, *Cirro-cumulus*, *Cirro-stratus*, *Cumulo-stratus*, and *Nimbus*.

Cirrus Clouds consist of slender white filaments, curling at times like a lock of hair, or arranged in parallel lines. They usually spread over the sky in light, feathery forms. Of all the clouds, the cirrus soars highest: it is supposed to be composed entirely of snow-flakes. Cirrus clouds are usually the precursors of a storm. They constitute the “cat-tails” and the “mackerel” sky of sailors.

Cumulus Clouds float near the earth. They are caused by the uprising of the heated air-currents. Cumulus clouds appear in vast rounded masses, which increase in size towards the hottest part of the day. They not unfrequently look like immense snowy mountains.



NOMENCLATURE OF CLOUDS.

Stratus or
Fall cloud.Cirrus or
Curl cloud.Cumulus or
Day cloud.Nimbus or
Rain cloud.

Stratus Clouds appear as level sheets of vapor, forming in the evening and melting away with the advance of the morning. They are almost always near the horizon.

Cirro-cumulus Clouds, a modification of the cirrus and cumulus, are fleecy clouds, occurring in small, rounded masses which lie near one another. They exist at various altitudes, and are seen in summer in the intervals of showers.



NOMENCLATURE OF CLOUDS—SECONDARY FORMS.

Cirrus.

Cirro-cumulus.

Cirro-stratus,
various forms.

Cumulo-stratus.

Cirro-stratus Clouds, which consist of bands of vapory threads more compact than those of the cirrus, group themselves into different forms. Sometimes they are composed of parallel bands, either distinct or blended at their centres; at other times they appear as long and slender bands. The slight vapory haze which occasionally dims the brilliancy of the sun is a form of the cirro-stratus.

Cumulo-stratus Clouds are formed when masses of cumulus clouds rise from the same horizontal stratum. Frequently contiguous clouds unite, and vast masses are piled upon one another like Alpine ranges. This is often the case before thunderstorms. In grandeur, no other clouds equal the cumulo-stratus.

Nimbus, or Rain-clouds, are usually formed from some of the preceding varieties. Frequently they consist wholly of rain-drops. These clouds first appear bluish-black in color, and then change to a light gray shade.

DEW.

15. **Dew** is the moisture which gathers on objects exposed to the atmosphere just after sunset.

Towards evening both the air and the land lose their heat by radiation. But the latter cools more rapidly than the former, and the stratum of air next the earth is cooled below the point of saturation. The excess of moisture then gathers upon various objects, in the form of dew.

Dew does not collect upon an object until the latter is colder than the surrounding air. The condensation of the moisture upon the outside of a goblet filled with ice-water illustrates the principle of the deposition of dew.

¹ From 5371 observations made at Skiddaw, a mountain in England, in 3270 observations the clouds were below the height of 3000 feet. It is probable that they are more frequently below than above a mile in alti-

tude. The thickness of cloud-strata is sometimes very great. Two French engineers measured amid the Pyrenees a stratum of cloud that was more than half a mile thick.

16. Deposition of Dew.—A cloudless sky favors the deposition of dew, because the radiation of heat from the earth then goes on unchecked, and the surface temperature sinks rapidly. But clouds arrest the radiation, and, the earth preserving its temperature, no dew is formed.¹



SNOW CRYSTALS.

More dew is deposited on a calm night than on a windy one, because but little of the air remains long enough in contact with the earth to be cooled below the dew-point.

Dew is deposited most abundantly upon bodies which have rough and pointed surfaces. Thus, down, wool, low shrubs, and grass are often drenched with dew; and on the rough-pointed leaves of the melon and cucumber dew sometimes begins to collect when the sun is yet high in the western heavens.

The reason is that uneven surfaces and points radiate heat very rapidly, and these bodies thus losing their heat are unable, being bad conductors, to supply their loss from the warmer substances with which they may be in contact.

In many instances no dew is deposited on rocks and metallic bodies in contact with the ground, for whatever loss of heat these bodies may sustain by radiation they regain from the warm earth. If bodies are screened from the open sky by trees or otherwise, the amount of dew is also materially lessened.

17. Distribution.—Dew is most abundant in maritime regions, while but little falls in the interior, except in the vicinity of lakes and along river-bottoms. In the temperate climes the amount of dew is small.² Within and near the tropic

¹ The effect of clouds is often very striking. Dr. Wells once observed the following changes: A thermometer exposed to a clear sky indicated a temperature of 32°; twenty minutes after, when the sky was overcast, it rose to 39°; in twenty minutes more, the sky being clear, it sunk again to 32°.

² According to Dr. Dalton, the annual quantity of dew in England would cover the whole kingdom with a sheet of water five inches in depth.

³ At times the falling snow gathers into masses formed by the aggregation of the flakes. In 1853 a singular occurrence of this kind was observed

countries the dews are very abundant, and drench the low verdure like rain. In many of the valleys of California and in parts of Asia it is so copious that for weeks it moistens the earth during the absence of rains, and sustains its vegetation.

FROST.

18. Frost is frozen dew. It forms when the temperature sinks to 32° or below it. The minute globules of vapor, being frozen as they are successively condensed, appear as a covering of delicate crystals.

Frost occurs most frequently at the beginning and close of winter, when the air is moist and the nights are cold. During the winter, when a warm and moist south wind occurs, the surfaces of stone walls and columns are often covered with an incrustation of crystals, formed in the same manner as frost.

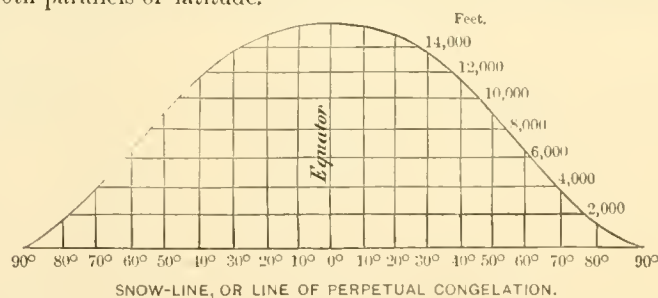
SNOW.

19. Snow is frozen vapor. When the temperature of the air sinks below the freezing-point, the moisture of the atmosphere is congealed, and descends in flakes of snow.³

In countries where the cold is intense, illustrations of the mode in which snow is produced are by no means of unusual occurrence. During the winter, when a window of a warm room is opened and the cold air is admitted from without, a shower of snow-flakes, caused by the instant congealing of the moisture, fills the air of the room.

20. Structure of Snow-Flakes.—When carefully examined by a magnifying-glass, the snow-flake is found to consist of delicate and regular crystals, combining in a great variety of beautiful forms. Its brilliancy and whiteness are due to the presence of air within the crystals. Scoresby, a celebrated Arctic explorer, observed no fewer than six hundred varieties.

21. Distribution of Snow.—No snow falls at the sea-level within the torrid zone and for a varying distance beyond it. In the Northern Hemisphere the southern limit of snow, termed the snow-line, is, for the greater part, included between the 20th and 40th parallels of latitude.



SNOW-LINE, OR LINE OF PERPETUAL CONGELATION.

As we ascend above the sea-level the amount of atmospheric moisture is diminished, and the snow-fall is less than in the lower districts; but an altitude is at length attained where, in every latitude, the falling moisture is constantly frozen, and the moun-

tain. While it was snowing fast and the wind was high, it seemed as if flocks of geese were descending to the ground. It was soon ascertained that this appearance was produced by balls of snow formed in the air by the action of the wind. Upon measuring these masses after their fall, some of them were found to be twenty inches in diameter. Red snow is sometimes found in the polar climes and on high mountains, its color being caused by the presence of a minute plant (*Protococcus nivalis*) which grows in those regions.

tain-ranges that tower above this limit are always clothed with ice and snow.

An imaginary line drawn from pole to pole through the altitudes where the moisture is always congealed is called the snow-line. Near the equator it is highest, being there about 16,000 feet above the sea-level; and from this point it gradually sinks toward the poles.

HAIL.

22. **Hail** is produced by the sudden union of an intensely cold body of air with one that is warm and humid.

In external appearance, hailstones are usually spherical masses, but sometimes they are irregular in shape. A section of the stone through the centre reveals its internal structure, which consists of layers of transparent ice alternating with white, snowy ice, the whole somewhat resembling the cross-section of a tree.



A GLACIER—MER DE GLACE, SWITZERLAND.

It is thought that the hailstone when first formed is small, and gradually increases from the moisture which freezes upon it as it descends. Hailstones vary greatly in magnitude, from the size of a pea to masses of several pounds' weight. Large stones are formed usually by the union of smaller ones.

AVALANCHES AND GLACIERS.

23. **Avalanches.**—Above the limit of perpetual snow the mountains are always covered with enormous masses of snow. A vast amount of snow accumulates between the altitudes of 6000 and 9000 feet. Some of this is removed by melting, a small amount evaporates, and a part of it is carried down the mountain-gorges in the form of glaciers. A great amount rolls down the slopes in the form of avalanches.

When the snow upon the steep mountain-sides is loosened, either by its own weight or by the wind, immense masses rush down the

¹ Under pressure the ice is broken and ruptured in every direction, but the moment the pressure is relieved the pieces of ice instantly weld or freeze together. This property of ice and snow is called *regelation*. The immense mass of ice which constitutes the glacier is impelled forward in its channel

slopes with irresistible violence into the plains below, destroying forests, burying villages, and arresting rivers in their courses.

24. **Glaciers.**—Glaciers are rivers of ice whose sources are above the line of perpetual frost. Usually, the glacier flows in a narrow valley, and extends several miles below the snow-line, reaching into the region of cultivated fields. Sometimes, however, it is a vast sheet of ice covering the whole slope of a mountain-range, and terminating at the sea. The glaciers of the Alps and of Mount Shasta are examples of the former; the famous Humboldt Glacier, in Greenland, of the latter.

Glaciers have the greatest altitude in the torrid zone. Their altitude decreases with the latitude, until, in polar regions, they reach to the sea-level.

The principal regions in which glaciers occur are the Arctic regions of North America and the Scandinavian Peninsula. They are numerous in Iceland, in the Alps, Pyrenees, and Caucasus ranges, and also in the slopes of the Himalaya Mountains.

On Mounts Shasta, Rainier, and Hood there are glaciers which in size rival those of Alpine regions. On the western slope of the Andes Mountains, in Chili and Terra del Fuego, almost every arm of the sea is terminated by a glacier.

25. **Formation and Structure.**—The upper part of the glacier is snow, sometimes compact and hard, but more often as light and fleecy as when it fell. The alternate thawing and freezing to which it is subjected soon change the minute snow-crystals to granules of ice, commonly known as *nèvé*. Still farther down the valley the *nèvé* becomes welded into ice, and finally the accumulation becomes a *river of ice*.

At first the ice of the glacier is tolerably smooth, but farther down it is seamed with cracks, called *crevasses*, which extend across it. In the lower part the crevasses grow wider and more irregular, and the surface of the glacier becomes a series of hummocks; streams of water from the melting ice begin to appear on the surface, and finally the ice gives place to a torrent of muddy water.

The color of the ice varies. At first it is of a dirty white color, and opaque. Farther down, patches of blue transparent ice appear, and in places the glacier is veined with alternate bands of blue and white ice.

The white ice is filled with air bubbles, and hence is opaque; but in places where it has been subjected to great pressure the air-bubbles have been squeezed out, and the ice acquires a beautiful blue color.

26. **Motions of the Glacier.**—The glacier flows in its channel precisely in the same manner as a river does.¹ Its current is swiftest in the middle at the surface, and slowest at the

by its own weight. But because the ice cannot stretch it must break, and become seamed with crevasses. The glacier is therefore being constantly ruptured across its mass, while the ruptured surfaces, brought into contact in other places, quickly unite by regelation.

sides and bottom. Moreover, the glacier-current increases or decreases as the slope over which it flows becomes more or less abrupt in inclination.

Because it moves fastest in the centre, crevasses form across the glacier, and where the slope is not too abrupt the lines of crevasses form a bow-shaped curve. In places where the slope becomes suddenly steeper, wide and very deep crevasses, called *bergschrund*, are formed. Similar crevasses are formed on the outer curve in places where the glacier changes its course.

The rate of flow varies from three or four inches to as many feet per day. It depends chiefly on the slope, but partly on the temperature. In summer, when the ice is rapidly melting, the velocity of the current is nearly twice as great as in winter. The velocity increases with the depth also. In the Alpine glaciers, whose depth is rarely more than two hundred feet, the velocity does not usually exceed three or four feet daily; but in Greenland, where the depth of the glacier is perhaps three thousand feet, it is often as great as fifty feet per day.¹

27. Moraines.—Fragments of rock and earth fall upon the glacier from the slopes that flank its sides. This loose matter accumulates along its borders, and is carried along with it. In many instances the detritus is crowded with such great force against the confining banks that it resembles an artificial wall of stone. These accumulations are called *moraines*.

Whenever two glaciers meet and flow in the same channel, the moraines on the sides which join unite, and form a *medial*, or middle *moraine*. Much detritus accumulates also in the channel, and is pushed ahead of the glacier, forming a *terminal moraine*. Not infrequently the terminal moraine is an immense barrier of boulders a hundred feet or more in height.

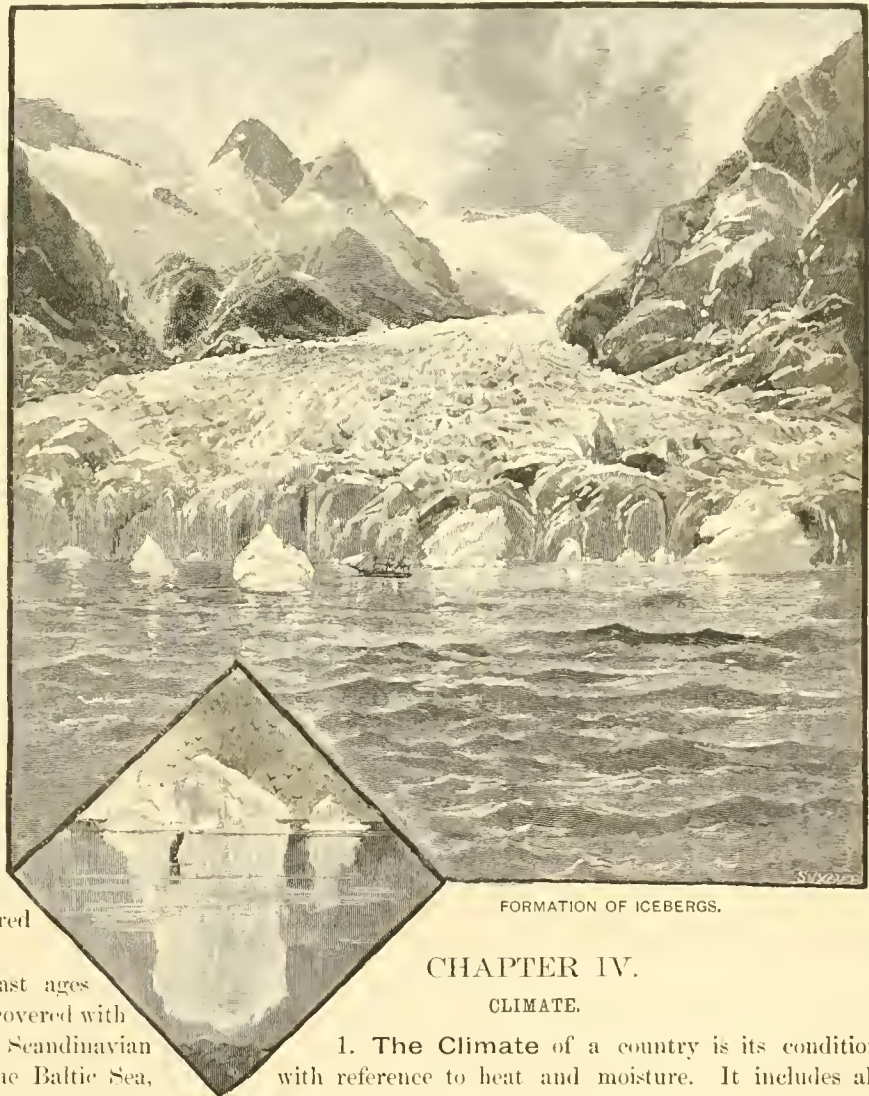
28. Glaciers of Former Ages.—During past ages much of the land of the Northern Hemisphere was covered with glacial ice. Immense glaciers, radiating from the Scandinavian Mountains, scattered their drift southward to the Baltic Sea, and westward to the frayed and ragged coast of the British Islands.

In North America the ice-flood moved as far southward as Kentucky. Its effects are best seen in the scored and ice-worn coast of the New England States, and along the chain of the great lakes.

29. Icebergs.—The glacier is the parent of the iceberg. In the regions where the glacier descends to the coast and pushes out into the ocean, the waves undermine it, until, from time to time, overhanging masses break off and fall into the sea. Usually, however, the mass of ice is gradually propelled farther and farther into the ocean, until at length it reaches water capable of supporting it. The iceberg then floats, and is borne away.

¹ The glaciers of the Alps are between five hundred and six hundred in number. They are estimated to cover an area of more than fifteen hundred square miles. Some of these are of considerable magnitude; thus, the Glacier des Bois, which terminates in the celebrated Mer de Glace, is fifteen

Icebergs in great numbers, detached from the glaciers of Greenland, float down the Arctic current until they meet the drift of the Gulf Stream, where they gradually melt. During the months of May and June they are so numerous along the route between New York and Liverpool that the ordinary sailing route between those ports is one of considerable danger.



FORMATION OF ICEBERGS.

CHAPTER IV. CLIMATE.

1. The Climate of a country is its condition with reference to heat and moisture. It includes all the effects of heat and cold, rain and drought, to which a region may be habitually subjected.

The climate of a region is modified by a variety of causes, the principal of which are latitude, height above the sea-level, position and direction of mountain-chains, table-lands, proximity or remoteness of the ocean, and prevalent winds and ocean-currents.

2. Latitude.—When the sun's rays fall vertically upon the atmosphere, more of them reach the earth than when they strike it obliquely. Since the axis of the earth is inclined $23^{\circ} 27'$ to the plane of the ecliptic, it is evident that the sun's rays will fall vertically only at some point or other within the tropics. Everywhere beyond these limits they strike the earth obliquely, the inclination to the earth gradually diminishing toward the poles.

miles long and three broad. One of these ice-cliffs in Greenland, the Great Glacier of Humboldt, rises as a solid glassy wall from an unfathomed depth three hundred feet above the ocean-level, and extends for a distance of sixty miles along the coast.

It therefore follows that the temperature decreases with the latitude. In advancing from the equator towards the poles we pass through every gradation of climate, from the fierce heat of the torrid zone to the eternal frost of the polar climes.¹

3. Height above the Sea-Level.—The temperature of a region depends also on its altitude. While the base of a mountain is parched with tropical heat its summit may be covered with perpetual snow. In ascending such a mountain we pass through the same gradations of climate as occur between the equator and the poles.

Thus, Mexico is divided into three different levels, characterized by distinct forms of vegetation. The *Tierras Calientes*, or hot district, includes all the regions which lie between the sea-level and the height of 2000 feet. Its mean temperature is 77°. The *Tierras Templadas*, or temperate district, is included between the altitudes of 2000 and 5000 feet, and has a mean temperature of 68°. The *Tierras Frias*, or cold district, is situated between the altitudes of 5000 and 8000 feet. Its mean temperature is not higher than 55°.

4. Position of Mountain-Ranges.—Mountain-ranges may extend in such a direction as to arrest rain-bearing winds and deprive them of their moisture. Thus, the Andes condense the moisture of the east winds, sending a deluge of water upon the pampas and silvas, but leaving the western slope dry and sterile.

In a similar manner the high crests of the Sierra Nevada and Cascade Mountains condense the moisture of the ocean winds, supplying the Pacific slope with copious rains, which would otherwise be carried far into the Great Interior Basin.

A more striking example may be seen in the Himalaya Mountains, which deprive the southwest monsoons of their moisture, flooding the southern slope of India and leaving the plains of Tartary with little or no rain.²

5. Maritime and Inland Climates.—A maritime climate is more uniform than a continental one; for, although a place on the sea-coast may have the same mean temperature as one in the interior, the range of temperature will be much greater in the latter. On the sea-side, therefore, the winters are mild and the summers cool, while in the interior the reverse is true.³

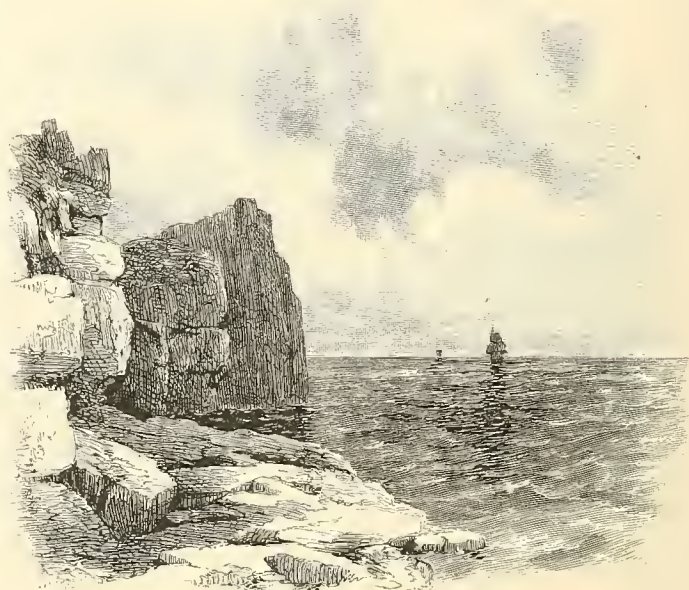
Thus, San Francisco and Chicago have nearly the same mean temperature for the year. But the mean summer and the mean winter temperature of San Francisco differ by only 8°, while in Chicago the difference is more than 40°.

Maritime countries are usually more humid than interior regions. On the eastern coast of Africa rains are abundant from Cape Guardafui to the Cape of Good Hope, while the vast plateaus to the west are dry and barren.

¹ The comparative lengths of day and night have also an important influence upon climate. When the days are long there is a great accumulation of heat under the continued action of the sun, while only a little is lost by radiation during the short nights. At the equator the days and nights are equal in length; within the tropics their inequality is slight; but in the higher latitudes they differ greatly in duration, while within the polar circles unbroken days and nights continue for months, alternating with the seasons. The variations of heat arising from the causes just mentioned are attended by corresponding variations in moisture. The effect of the solar heat extends but a short distance below the surface of the soil: at a depth varying from about forty to one hundred feet a stratum of earth is reached where the temperature never changes, being constantly about the same as the mean temperature of the country above it. It will be readily seen that this stratum lies deepest in the hottest countries.

² Lofty plateaus exert a powerful influence in modifying climate. This is strikingly shown in the Himalayas. On the southern side the extreme limit of cultivation is 10,000 feet above the sea-level, and nothing but low shrubs

6. Prevailing Winds.—The direction of winds, and the nature of the surface over which they blow, modify climate. Sea-breezes are moist, while land winds are commonly dry. The southwesterly winds of the Atlantic, warmed by the Gulf Stream, soften the climate of Western Europe, and give it a mean temperature many degrees higher than that of the regions situated in the corresponding latitudes of America. The southwesterly breezes of the Pacific give, in like manner, a higher mean temperature to the western coast-regions of North America than is enjoyed on the eastern shores of Asia in the same latitudes.



NORTH CAPE.

The winds from polar seas have a free course on the Western Hemisphere, sweeping over the vast northern plains. Deflected by the Rocky Mountains, they become the dry and cold north-westers so well known in the United States.

7. Ocean-Currents.—The effect of ocean-currents on climate has already been noticed. The mass of warm water borne northward by the Gulf Stream softens the climate of the South Atlantic States and of Western Europe. The same effect is produced along the shores of Northwestern America by the Kuro Siwo. The Antarctic Current tempers the hot climate of the Peruvian coast, and the Arctic stream moderates the burning heat of Central America.

8. Cultivation.—In countries covered by dense forests the winters are more uniform in temperature than in dry, cultivated

grows at the height of 13,000 feet; but on the northern declivity, at the last-named altitude, fields of barley abound, and flowers in rich profusion meet the eye, while a little below are extensive vineyards and groves of apricots. At the height of 17,000 feet, in the latitude of 30°, the ground is covered with the tama-bush. The cause of this difference in climate is the sandy table-land of Tartary, which, at the height of 10,000 feet, stretches out its immense expanses north of the Himalayas. The radiation of heat from this arid and elevated region, increased by the serenity of its atmosphere, mitigates the climate on the northern slopes of the Himalayas, and forces up the snow-line many thousand feet above its position on the southern side. In the vicinity of the plateau of Bolivia the same result is seen, the snow-line on the Bolivian Andes being 2000 feet higher than it is at the equator.

³ At North Cape, which has the same mean annual temperature as Irkutsk, Siberia, the mean summer temperature is 43°, and the mean winter temperature 23°. At Irkutsk the respective mean temperatures of summer and winter are 60° and 0°.

regions; while during the summer season the latter have the higher temperature.

When forests are levelled and the surface of the earth is thus exposed to the warmth and light of the sun, the climate becomes much less uniform in temperature.¹ During the past six hundred years the climate of Western Europe is said to have been thus considerably changed.

The healthfulness of many regions is materially affected by the noxious exhalations of the soil. This is especially the case on the low and humid coasts of tropical countries exposed to the intensest heat of the sun. Here, from the stagnant waters of the lagoons, rises the miasma, which fills the air with the germs of pestilential fevers.²

ISOTHERMS.

9. **Isotherms**³ are lines drawn through places which have the same mean annual temperature. On account of the great difference in the distribution of heat from the equator to the poles, it might be supposed that isothermal lines would nearly coincide with the parallels of latitude. This, however, is not the case, for the influences already considered produce wide departures.

By inspecting the map on page 88 the deviation of the isotherms from the parallels of latitude will at once be seen. It is noticeable that the isothermal curves extend farther to the north on the western coasts of the two great continents than on the eastern. This is due to the warm ocean winds from the southwest which strike the western coasts.

The *warm equator*, or isotherm of greatest heat, is north of the geographical equator. The causes of these deviations have already been explained.

The geographical north pole of the earth is not the coldest region in the Northern Hemisphere. The two regions of most intense cold are in about the 80th degree of north latitude, one being in America and the other in Siberia.

10. **Zones of Climate.**—Certain important isothermal lines may be regarded as dividing the surface of the globe into zones of climate, characterized as *hot*, *warm*, *temperate*, *cold*, and *frigid*.

The Hot Zone is bounded by the isotherm of 79°. Here, wherever moisture abounds, a rank and luxuriant vegetation clothes the earth; but where it fails, nothing meets the eye but vast deserts, glowing with intense heat. Within this zone no snow or frost is found at the sea-level.

The Warm Zone extends to the isotherm of 68°. It possesses the characteristics of the hot zone, but in a modified degree. Burning deserts here alternate with a luxuriant vegetation wherever moisture abounds.

The Temperate Zone is bounded by the isotherm of 32°. In the Northern Hemisphere it includes most of North America, the whole of Europe, and Central Asia. Within it, tropical vegetation disappears and the bread-grains flourish. Man here attains his highest development; and this region is consequently the abode of the dominant races of the earth.

¹ "When our ancestors came to New England the seasons and weather were uniform and regular. Autumn began with September, and the winter set in about the end of November, continuing till the end of February, when the spring began, and advanced without sudden fluctuations in temperature. The summer lasted but six weeks, and was insufferably hot. Now the seasons are totally altered, and the weather is far more changeable: the autumn begins and ends later, and the winter does not set in in its severity before the end of December."—WILLIAMSON.

² The Campagna of Rome, once the garden of Italy, but now desolate and filled with sluggish waters, has become unhealthy from the malaria

The Cold Zone extends to the isotherm of 10°. Here the ground, at varying depths, is constantly frozen; but the heat of the brief summer suffices to mature wheat, rye, and barley.

The Frigid Zone extends beyond the isotherm of 10°. Here ice and cold reign supreme. Evergreens are found near the southern border of this tract; but mosses and lichens cover the expanse of land which stretches towards the pole.

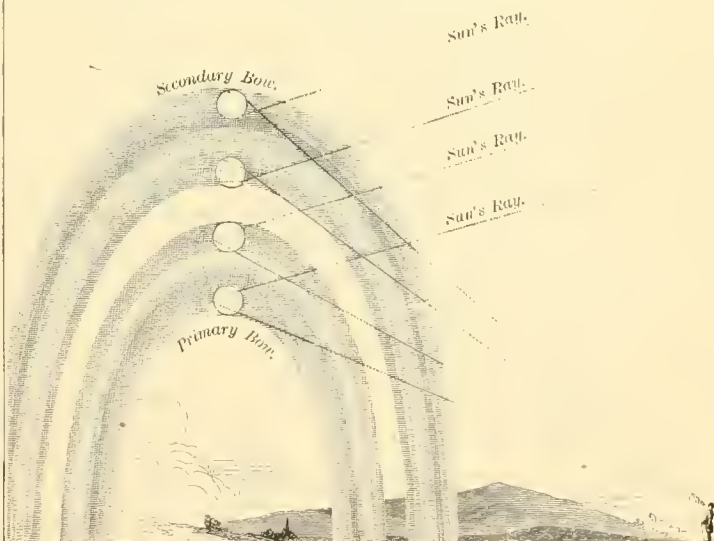
CHAPTER V.

OPTICAL AND LUMINOUS PHENOMENA.

1. **A Ray of Sunlight** consists of colored rays blended together. These may be separated by *refraction*. When the ray of light passes through a triangular prism of glass it is decomposed into three principal colors, *red*, *green*, and *violet*. The red is least refracted, and the violet most. By combining these, various compound colors, such as purple, blue, yellow, orange, and others, are formed.⁴

OPTICAL PHENOMENA.

2. **Rainbow.**—The rainbow is an arch of colored light which is seen when rain is falling and the sun shining at the same time. It is seen when the back of the observer is turned to the sun. An imaginary line drawn from the sun through the eye of the observer towards the bow passes through its centre. A different bow is therefore seen by each spectator.



RAINBOW—PRIMARY AND SECONDARY BOWS.

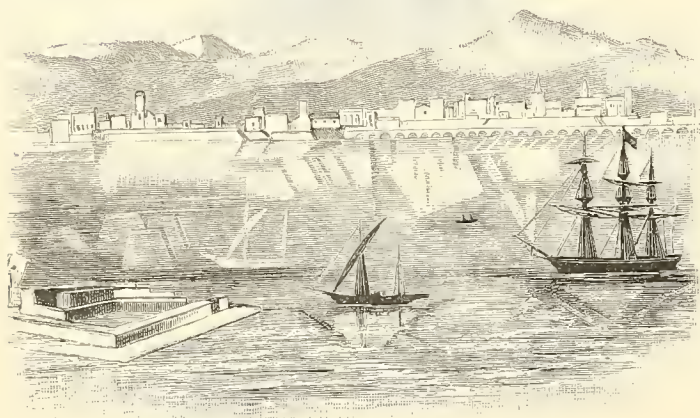
When the bow is complete, it consists of two arches of colored light—the inner or primary, and the outer or secondary bow—

that infects its atmosphere; and the inhabitants retreat to the higher ground as the sickly season approaches. When the soil of the primeval forests and of the prairies is first broken up and exposed to the sun, miasma prevails, producing remittent and intermittent fevers.

³ From the Greek words *isos*, equal, and *thermē*, heat.

⁴ Light is also decomposed by *absorption*. A red rose receiving the white light of the sun absorbs all the prismatic colors except the red, which it reflects, and by which it is visible; and so of other colored objects. A white object, as a water-lily, *reflects* the prismatic colors in due proportion; while a black object, as charcoal, *absorbs* a portion of all of them.

each composed of prismatic colors. In the primary bow the red is uppermost, and the violet lowest; in the secondary, the position of the colors is reversed.



FATA MORGANA, AT REGGIO.

When a ray of sunlight strikes a falling drop it is decomposed into prismatic colors, is then reflected from the surface of the drop, and is at last refracted again into the atmosphere.¹

Beautiful bows are beheld in the spray that rises from cataracts, and the clouds of mist that ascend from Niagara always exhibit this wonderful phenomenon.

Lunar Bows are formed in the same way as the preceding; but, on account of the feeble light of the moon, they are rarely observed and the colors are indistinct.

3. Color of the Atmosphere and the Clouds.—The rays of the sun, on their way to the earth, pass through the atmosphere, whose strata differ in density, and they are consequently more or less refracted and decomposed.

The blue and the violet deviate most from their original directions, and are, consequently, dispersed throughout the atmosphere. Being reflected from floating particles of the air, they therefore impart to the sky its azure hue.²

If we look at a candle-flame through a thin piece of porcelain it appears of a red color, because the porcelain has absorbed all the colors in the flame, except the red. In a like manner, at dawn and at sunset, the solar beams, traversing the atmosphere and the vapors that float within it, lose by absorption all their colored rays except the least refrangible, as the red and orange. These penetrate the clouds near the horizon, and cause them to glow with rich, golden colors.

On this account the most common colors of clouds are red,

¹ The rays of the primary bow come to the eye after *one reflection* and *two refractions*; those of the secondary, after *two reflections* and *two refractions*. A tertiary bow, formed by *two reflections* and *three refractions*, is also possible; but as it is situated near the sun, and as a great amount of light is lost by so many reflections and refractions, it is extremely faint, and is rarely seen. The circular form of the bow is due to the fact that the red rays, for instance, which come from the rain-drops to the eye of the observer, must always make the same angle around the imaginary line proceeding from the sun to the eye of the observer. The red rays, therefore, must form a circular arch around this line; and so with all the other colors of the bow.

orange, and yellow, with their various shades; but at times they are radiant with many other hues, and in California and India the sky is often tinted with green and violet.

4. The Mirage.—The mirage is an optical illusion in which objects are seen reflected either from the clouds or from the surface of a layer of air. Instances of this phenomenon are of common occurrence. Captain Scoresby, while in the Arctic seas, once recognized his father's vessel by its inverted image in the air, though it was at the time seventeen miles beyond the horizon.

An extraordinary spectacle of this kind is the Fata Morgana, which is sometimes seen at Reggio, on the Strait of Messina. Under certain atmospheric conditions there appears an image of the city on the surface of the water, and another equally distinct inverted in the air.

A fine mirage is at times visible on the shore of Lake Michigan. During sultry summer days at Hyde Park, or at Fairview, one may frequently see the images of the lighthouse, tunnel-crib, and shipping inverted in the air.

The most perfect of these illusions, however, is the mirage of the desert, which nearly always presents the appearance of a lake studded with islands. On the hot arid plains of California, Arizona, and Texas this phenomenon may be seen almost daily. Sometimes the illusion is so perfect that even the herds of cattle are deceived by it.

During the march of the French army under Bonaparte over the Egyptian deserts, the villages appeared each to be surrounded by a lake, on the surface of which the buildings and trees were reflected.



MIRAGE OF THE DESERT.

The mirage in every case is caused by the reflection of light, and the reflecting surface in nearly every instance is the surface

² The blue color of the sky is thought to result from the presence of minute particles of matter floating in the atmosphere, from which the blue rays of light are reflected. The intensity of the blue tint of the atmosphere increases from the horizon to the zenith; for the light vapors that settle upon the earth and mingle with the atmosphere lessen its brilliancy. For a similar reason, the sky in the temperate regions has a paler tint than in the tropics, where the vapors are absorbed, and it glows with the richest azure. In Arctic climes, where the atmosphere is rendered pure by the precipitation of the vapor, the same result occurs, and the skies, in depth of color, rival those of the tropics.

of a layer of air differing in density from the air above it or below it. The reflecting surface behaves in every respect like a mirror. If it be above the eye of the observer, the object will be seen

ness of the sun to detect the faint hues of the corona. It is rarely that the corona displays prismatic tints.

LUMINOUS PHENOMENA.

7. Meteorites.—Meteorites are solid fiery bodies, which sweep through the atmosphere with great velocity, and are commonly attended by a luminous train. Not infrequently they burst into pieces, and the fragments fall to the earth. These fragments are called *meteoric stones*, and are usually composed of iron and nickel.

Such phenomena have been constantly taking place from the earliest times, in all parts of the globe, and scarcely a year passes without their occurrence.³

In 1860 a meteorite passed over Virginia and Ohio. It appeared as a blazing ball of fire, followed by a brilliant train of light, exploding with a loud noise. After the explosion a large number of fragments fell throughout an area ten miles long and three miles wide. The largest stone weighed one hundred and three pounds, and penetrated into the earth between two and three feet. The height of the meteorite above the earth was about forty miles.

8. Shooting-Stars.—Shooting-stars, or meteors, are luminous bodies that dart noiselessly through the sky, followed by a bright train. Solitary shooting-stars are of common occurrence throughout the year, but in August and November they are very



PARHELIA.

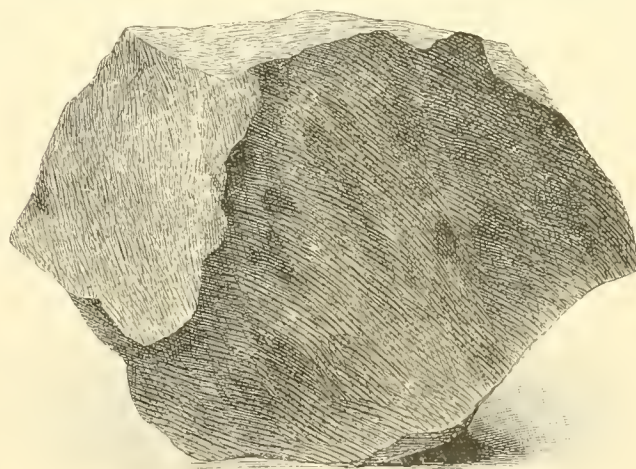
inverted in the air; if below, the image will be reflected apparently from the surface of a lake; and because the surface of a lake or a pond is also a mirror, the mirage of the desert is often so perfect as to deceive travellers of experience.¹

5. Halos.—Halos are circles of prismatic colors surrounding the sun and the moon—the violet being the outer color, and the red the inner. The breadth of the ordinary halo is about half the distance from the horizon to the zenith, and the extraordinary halo has twice this extent.

At times the ordinary and the extraordinary halo are seen simultaneously, while other colored circles intersect them. Whenever the circles cross one another the light accumulates, and brighter spots occur. These are commonly termed *parhelia* and *paraselenae*, or mock suns and moons.

On the theory that cirrus clouds consist of ice-crystals, halos can be satisfactorily explained by supposing that a stratum of such crystals is floating before the sun, and that the rays of the latter are refracted by traversing these minute prisms.²

6. Coronas.—Coronas, like halos, are circles of prismatic light surrounding the sun and moon. They are seen when light vapors partly veil the sun or the moon. They more frequently encircle the latter, for the eye is usually too much dazzled by the bright-



METEORIC STONE.

(Which fell in Ohio, May 1, 1860.)

numerous, and hundreds may be seen from a single point of observation flashing across the sky. The November shower of meteors recurs at intervals of about thirty-three years.⁴

¹ The shadows of objects, magnified by reflection, are sometimes seen projected upon the clouds and sky. On several occasions, as persons were standing in front of the Mountain House, at Catskill, New York, each person beheld his own shadow, of huge dimensions, cast on the clouds before him. In Perthshire, Scotland, there stands upon the lofty hill of Dunmore an obelisk seventy or eighty feet high. More than once a perfect shadow of the hill and obelisk has been projected on the northern sky at the distance of two miles. The phantom of the Brocken, so famous in German legends, is probably an appearance of the same kind.

² If we look at a street-lamp through the frost-work on a pane of glass, a halo, caused by the refraction of the light in passing through these ice-prisms, is seen surrounding it. An analogous phenomenon is presented at rare intervals when the sun is near the horizon. It is an upright column of light, of great beauty, tinged with prismatic hues; and with it are sometimes seen images of the sun which rival the true sun in splendor.

³ According to Livy, a shower of stones fell upon Mount Alba in the

reign of Tullus Hostilius, about 650 years before Christ; and another is mentioned by Cesar that descended at Acilla, in Africa. Near Milan, in the year 1510, the phenomenon was attended by a fall of stones in number about 1200, two of which weighed respectively 60 and 120 pounds.

⁴ In November, 1799, Humboldt and Bonpland, then in South America, beheld a shower of falling stars which lasted four hours. Their flight was marked by a luminous path, which continued visible for several seconds. A few of these bodies exploded, but nearly all disappeared without scintillation. In November, 1833, another star-shower occurred, which was still more magnificent. For the space of seven hours the heavens blazed with an incessant discharge of fiery meteors, many of them equalling in size and brilliancy the largest stars. It was estimated that at this time no less than 240,000 meteors fell. The recurrence of the November shower in 1866 was confidently predicted by meteorologists: in America the display of meteors was not remarkable; but magnificent star-showers were beheld in Scotland and in Syria on the morning of the 14th of November.

Various theories have been advanced to account for this periodic display of meteors. It is now generally believed that it is due to a vast number of small bodies which revolve around the sun in an orbit crossing that of the earth.



IGNIS-FATUUS.

Every year when the earth reaches the point where the two orbits intersect, many meteors are drawn to the earth. But when the earth and the great mass of meteoric bodies reach the point of intersecting orbits at the same time—which occurs every thirty-three years—there is a brilliant display, and millions of these minute bodies are brought within the earth's attraction. They then fall through the atmosphere with such great velocity that they are vaporized by intense heat.

9. **Ignis-Fatuus.**—The Ignis-Fatuus, commonly called Jack-o'-Lantern, or Will-of-the-Wisp, is a flickering, movable light which hovers over low meadows and marshes. It is generally of a pale-red or a bluish color.¹

CHAPTER VI.

ELECTRICAL PHENOMENA.

1. **Electricity** is a form of energy of whose nature we are ignorant, and which is known by its effects only. It is seen in its simplest developments when sparks are produced by rubbing a glass tube with a piece of silk. It is displayed in its grandest form when vivid lightnings illumine the darkness of the storm.

Electricity exists in two conditions, called for convenience *positive* and *negative*. These are developed simultaneously: thus, when produced by friction, the rubber has one kind of electricity, and the body rubbed the other. *Bodies similarly electrified repel one another; bodies differently electrified attract one another.*

¹ In May, 1821, a very fine display of the ignis-fatuus was witnessed in the marsh of Chapelle-aux-Planches, in France. It resembled a pyramid of pale red light, ten or twelve feet high, and was so bright that a person could read by it. The ignis-fatuus is supposed by some authorities to arise from the gases caused by the decay of animal and vegetable substances, which, igniting in contact with the atmosphere, become phosphorescent.

² It is, however, subject to great and rapid changes in this respect.

³ During the Mexican War there occurred to a detachment of soldiers, on their march to Vera Cruz, an incident which strikingly illustrates the intensity of the tropical thunder-storm. The story is thus related by the

Substances which transmit electricity with facility, like *metals* and *water*, are termed conductors; those through which it passes with difficulty, such as *gutta-percha*, *shellac*, *glass*, and *silk*, are called non-conductors. Dry atmosphere is a non-conductor.

2. **Origin.**—No mechanical or chemical change can occur without the development of electricity.

1. Friction is a source of atmospheric electricity. The ripple of the brook, the winds that chafe the mountains or rock the forests, produce electricity.

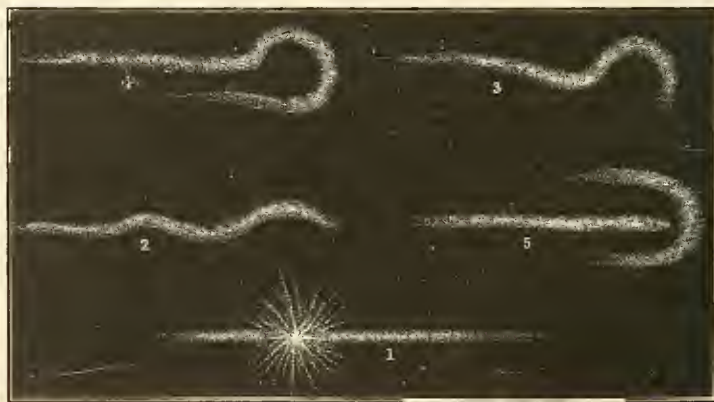
II. Evaporation is another source, and a very energetic one; for a vast amount of vapor is constantly rising from sea and land and filling the recesses of the atmosphere. When this vapor is condensed, electricity is again developed.

III. Condensation is therefore another source of atmospheric electricity. Its amount is still further increased by the processes of combustion and vegetation; for wherever a fire is kindled, or a plant springs from the soil, electricity is generated.

3. **Polarity of the Atmosphere.**—The electricity of the atmosphere in its ordinary state is *positive*, and it increases in intensity with the altitude.² It is more intense during storms than in fair weather, and often changes suddenly at such times from positive to negative, and the reverse.

It is stronger in winter than in summer, and twice in the day it also changes in strength, being most intense about eight A.M. and eight P.M., and weakest near sunrise and a little before sunset. The earth is charged ordinarily with *negative* electricity.

4. **Thunder-Storms.**—When large bodies of air, differing in temperature and charged with humidity, are rapidly mixed, electricity is developed on a vast scale. As the clouds form and the rain descends, vivid flashes of lightning alternate with the crash of thunder.



METEOR OF SEPTEMBER 30, 1850.

(The figures show its successive transformations.)

As the causes that produce the storm decrease in energy towards the poles, thunder-storms are less violent and frequent in the high than in the low latitudes.³

surgeon of the regiment: "The storm burst suddenly upon us, the lightning blazing down in vivid columns, followed quickly by sharp reports of thunder. I felt a sudden bewilderment, and then lost all consciousness. I was aroused from my stupor by some officers, who asked what could be done for myself and the soldiers. I turned my eyes upon the regiment, and beheld a most appalling sight. One entire company was stricken to the earth, their arms lying in irregular heaps beside them. Very soon I was able to give directions to relieve the sufferers, and was rejoiced to find that most of them were only shocked by the electric fluid that had run along the ground."

5. **The Lightning-Stroke.**—When electricity is generated in the atmosphere, it accumulates at the surfaces of clouds that float within it. Some clouds are charged negatively, others posi-



ST. ELMO'S FIRE.

tively; and if two clouds differently electrified approach each other, they are mutually attracted. As they continue to approach, the electric attraction at length becomes so great that the resistance of the intervening air is overcome, and the two electricities combine in a flash of lightning. This interchange also frequently takes place between the earth and the clouds.

In appearance, flashes of lightning differ according to the resistance of the intervening mass of air. They are commonly described as zigzag, ball, and sheet lightning.

Zigzag lightning appears like a broken chain. It is sharply defined, and often separates into distinct branches between the clouds and the earth.

Ball lightning is a rare phenomenon, in which the electricity takes the form of a globe of fire, and advances with a slow motion.¹ The cause of its extraordinary shape is not known.

Sheet lightning occurs when the flash expands and diffuses a glow of light over the clouds, rendering their outlines distinctly visible. It commonly arises from the noiseless interchange of electricity between the atmosphere and the earth.

6. **Thunder.**—When the lightning-flash occurs, it produces a sudden and powerful displacement of the particles of the air along the line of its passage. Into this partial vacuum the air rushes, and the thunder is the effect of the violent collapse. The rolling of thunder arises from the circumstance that the sound from different points reaches the ear in a succession of intervals.²

¹ An instance of this kind was witnessed by Captain Home, of the ship Dyer. The wind was blowing from the southwest, and the weather squally, when a globe of fire about six inches in diameter was seen coming from the northeast. It struck the foretop-sail of the ship and burst with a report like that of a cannon.

² Atmospheric electricity affects the wires of the telegraph. The electricity developed during a snow-storm has been known to operate the telegraph machines; and in thunder-storms, violent explosions often occur not only when the wires are actually struck, but by the inductive action of a storm, without any transfer of electricity. Sometimes the current follows the telegraph wire, fusing the fine wires of the instruments in its passage.

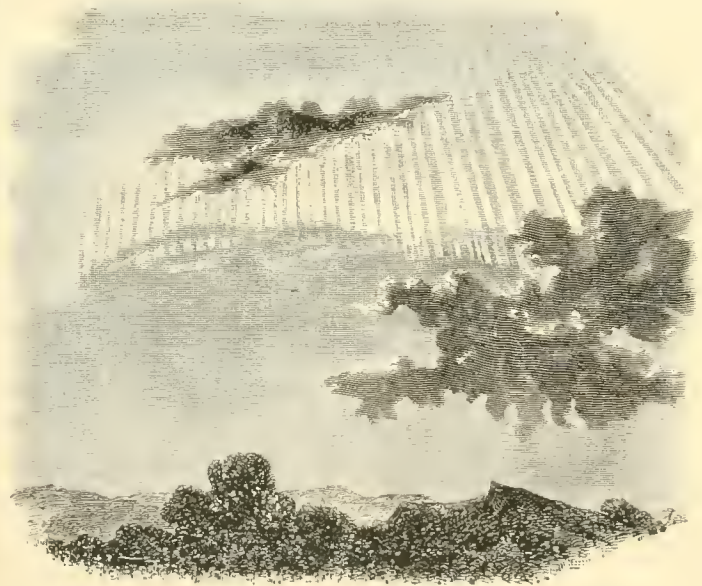
7. **St. Elmo's Fire.**—This name is given to the pale light that tips the extremities of objects during a highly electric state of the atmosphere.

It is a peculiarity of electricity that it escapes most freely from points; and when any part of the surface of the earth is intensely electrified, the interchange between the atmosphere and the earth is most energetic at the extremities of pointed objects, as the tops of masts, or of steeples.³

8. **Lightning-Rod.**—In 1752, Franklin made his celebrated experiment of drawing lightning from the clouds by the aid of a kite, which he raised upon the approach of a thunder-storm. In this manner he performed all the common electrical experiments, thus proving the identity of lightning with electricity. The invention of the lightning-rod was the fruit of this discovery.⁴

9. **The Aurora Borealis, or Northern Light.**—The Aurora is a luminous phenomenon sometimes observed in the northern sky. It is also seen in high southern latitudes, where it is called the Aurora Australis, or Southern Light.

When most brilliantly displayed, the aurora consists of a luminous arch, from which clouds of light suddenly appear, and stream upward like tongues of fire. These streamers glow with tints of crimson, yellow, and green, and dart far up into the sky with a tremulous motion.

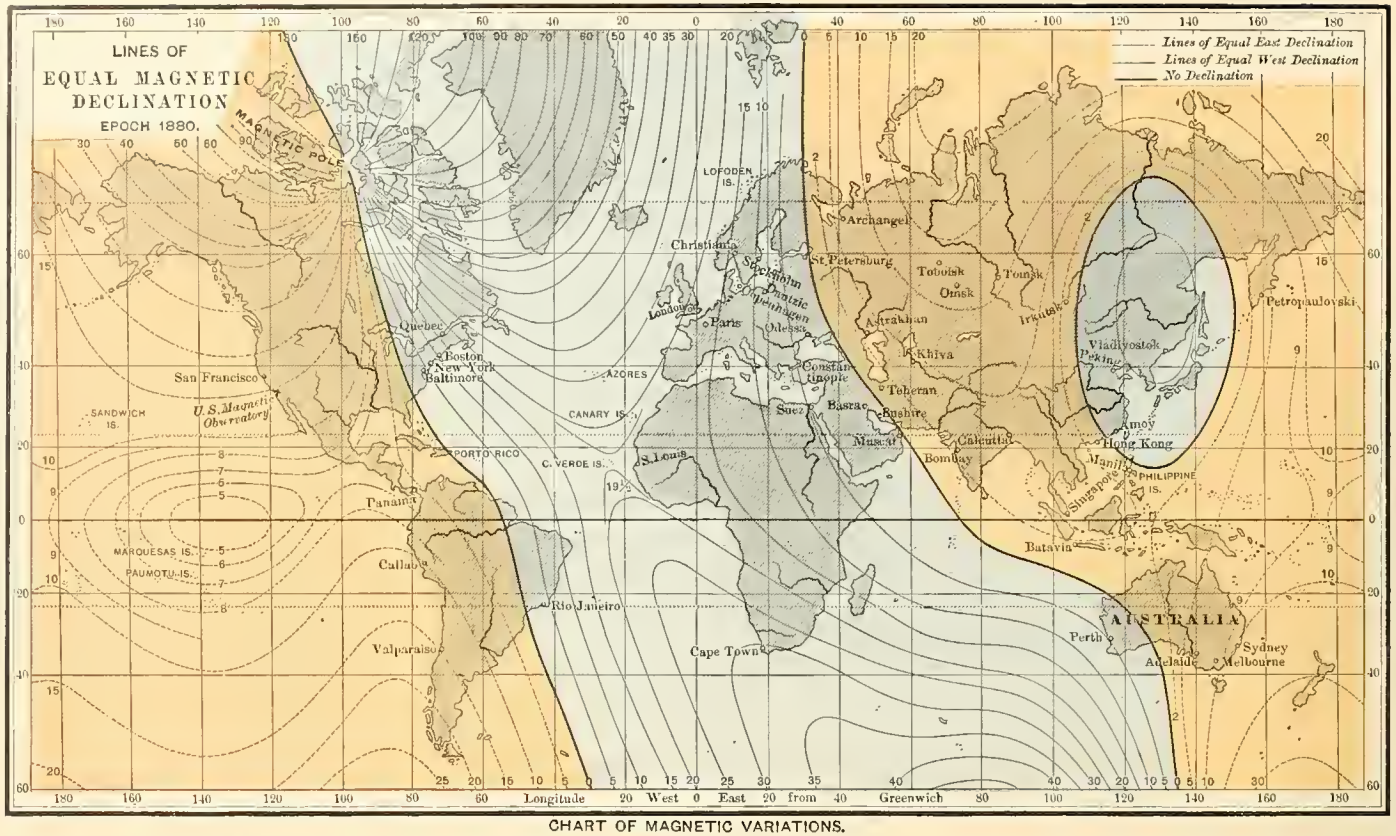


AURORA BOREALIS.

In the ordinary auroras seen in the temperate zones the corona is not found, and the brightest tints are wanting; yet at times within these limits splendid exhibitions occur. In the polar regions they are beheld in the greatest magnificence. There the

³ Cesar relates that during the African war, in the month of February, a storm of hail occurred, in the second watch of the night, when the spears of the fifth legion appeared as if tipped with fire.

⁴ The lightning-rod is a metallic rod erected upon buildings and the masts of ships. It should be pointed at the upper end, rise above the objects it is designed to protect, be continuous, and terminate below in water or moist earth. It affords protection from lightning because the electricity, in its passage between the clouds and the earth, is transmitted with greater facility through the rod than through the building or vessel on which it is erected. The lightning-rod protects a space around it to a distance equal to twice its height.



arches, their vivid streamers flushed with the richest prismatic hues, are seen passing successively over the heavens and forming brilliant curtains of light. The corona is rarely seen north of the 70th parallel.¹

The origin of the aurora is due to electricity. During its occurrence, all the varied and well-known effects of electricity are exhibited. Powerful electric currents are developed on telegraphic wires, so that in many instances streams of fire flash along them, setting fire to the offices through which they pass.

10. Uses of Electricity.—Currents of electricity, circulating around the earth, render it a magnet, and cause the compass-needle of the mariner to point to the northern magnetic pole. Upon this instrument, thus directed, depends the commerce of the world. Man has subdued this mighty power, and it now works at his bidding.

Cities are lighted by electricity, and metals are plated with gold, silver, and nickel by its action. The pages of this book are printed from a copy of the original type, taken by the moulding power of electricity.

But, more than all, across continents and through the depths of the ocean we now communicate by the telegraph wire, and, by means of the telephone, audible conversation may be carried on between two persons a thousand miles apart.

TERRESTRIAL MAGNETISM.

11. Magnets are bars of steel which have the property of attracting iron and nickel. When freely balanced on a pivot, a

¹ One of the most extensive and splendid auroral exhibitions on record occurred in 1859. It extended over every meridian of the Northern Hemisphere, and was seen from about the 60th degree of north latitude to the 50th degree of south latitude. Throughout the whole of this vast region the aurora was displayed in all its varied phases of magnificence and beauty. Luminous arches spanned the heavens, resting upon crimson masses of light, while streamers brilliant with hues of crimson, scarlet, orange, yellow, green, and purple, flashed upward through the sky.

magnet tends to assume a fixed direction. This property is called *orientation*.

12. Magnetic Poles.—The property of magnetic attraction may be best observed by plunging a bar magnet into iron filings. It will be noticed that the filings do not cling to all parts of the magnet, but adhere chiefly at the ends.

The ends of the bar are called its *poles*;² the middle of the bar, the *neutral* part. The intensity or strength of the magnet is greatest at the poles; at the neutral part it disappears.

Either pole of a magnet attracts bits of soft iron indifferently; but if two magnets be suspended a short distance apart it will be found that, while their unlike poles attract, their like poles repel each other.

12. The Earth's Directive Force.—A magnet freely balanced on a pivot is commonly called a *magnetic needle*. When thus balanced it comes to rest in a direction which is nearly or quite north and south. The pole pointing to the north is called the *north-seeking*, or —, pole; that pointing southward, the *south-seeking*, or +, pole.³

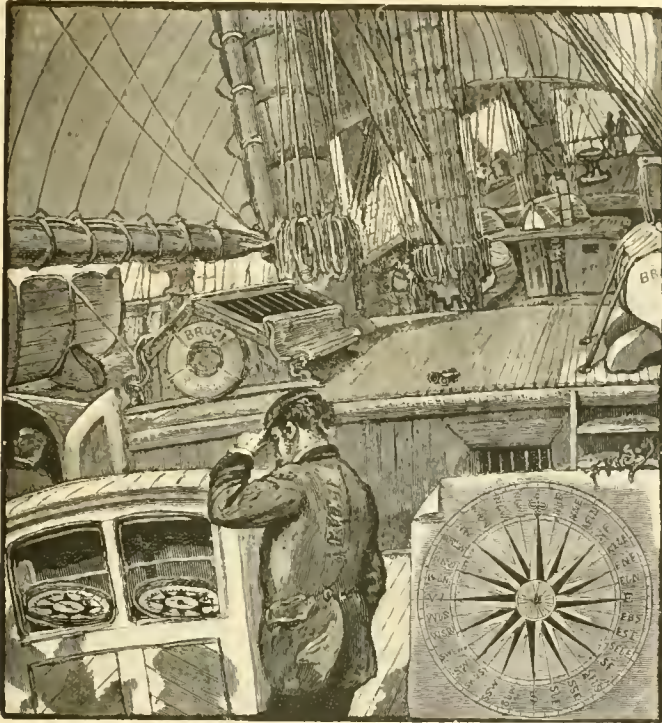
A slender piece of steel suspended from a strand of fine silk, and perfectly balanced, will not retain its horizontal position after it has been magnetized: one pole will then be attracted to the earth, while the opposite pole will be repelled.

Thus it is evident that the earth itself behaves towards a magnet just as one magnet behaves towards another. The north magnetic pole of the earth attracts the south magnetic pole of the needle, and *vice versa*.

² A long bar, or one made from steel of poor quality, may have several poles scattered about its mass. For making serviceable magnets only the best quality of steel should be used.

³ They are called the *marked* and the *unmarked* pole, and also the *negative* and the *positive* pole, in order to avoid the more common but incorrect expression, "north" and "south" pole. Because *unlike* poles of a magnet attract each other, the true north pole of a magnet points south, and *vice versa*.

13. The Compass.—The compass consists of a slender piece of magnetized steel, so mounted that it turns freely on a pivot. Usually it carries a sliding weight, which is so adjusted as to balance the dipping or vertical force, and keep the needle in a horizontal position.



MARINER'S COMPASS.

In the mariner's compass the needle is fastened to a circular card, on which are printed or indicated the cardinal directions, subdivided into the thirty-two parts which are commonly called the "points" of the compass.

Ordinarily the card, which is constructed of very light material, turns on a pivot. In compasses of great delicacy the compass-box is filled with alcohol, in which the card and needle rest so lightly on the pivot that they almost float.¹

14. Magnetic Declination.—The compass-needle does not always point towards the geographical poles of the earth. There are, indeed, but few places where it does. The reason will be found by inspecting the chart.

The needle points always towards the magnetic poles, and these are not situated at the geographical poles. The north magnetic pole is situated in Boothia Land, about 20° distant from the earth's pole.

¹ In the Arctic seas, where the horizontal force is feeble and the vertical force strong, sailing by the compass is attended with no little difficulty. It is especially difficult in Baffin Bay, where the declination varies from 50° to 80° . On whaling vessels it is customary to attach a string to the compass-box. By this means the steersman occasionally gives the compass a sharp jerk to make the needle better indicate the direction.

² From Greek words meaning *without an angle*—that is, not deflected or turned from the true meridian.

³ The magnetic equator is an irregular line near the geographical equator, but not coinciding with it.

⁴ In the United States the yearly variations are greatest in the north-western part. In Washington Territory and Alaska the declination changes at the rate of nearly $7'$ each year. In Arizona and New Mexico there has been little or no change for several years. In the New England States the annual change varies from $1'$ to $3'$ $30''$.

⁵ The changes in declination at Paris have been carefully observed during

The heavy lines marked 0° on the map are called *agonics*,² or lines of no declination. Everywhere on this line the compass-needle (in 1880) points north and south. East of the agonic the pole of the needle swerves to the west; west of the agonic it turns to the east. The fine lines are called *isogonics*, or lines of equal declination.

The isogonics approach one another in the northern part of North America, and finally intersect at the *magnetic north pole*. There is a supplemental magnetic north pole in Siberia, but it is not well defined. The position of the magnetic south pole is not with certainty known.

15. Magnetic Inclination.—Magnetic inclination, or "dip," is the variation of a suspended compass-needle from a horizontal position. At the magnetic north pole the compass-needle takes a vertical position, the north-seeking, or —, pole of the needle being next the earth.

If the dip-compass be carried southward, the needle will gradually assume a horizontal position, until at the *magnetic equator* its dip or inclination will be 0° .³

South of the magnetic equator the needle again dips, this time the south-seeking, or +, pole inclining. The dip increases until, at the magnetic south pole, the needle is again vertical.

16. Change of Variation.—Neither the declination nor the inclination of the magnetic needle remains unchanged for any great length of time. At nearly every place where observations have been made, it has been found that the variations are changing each year.⁴

Not only are changes in variation taking place in all parts of the earth, but the rate of change is itself subject to great variation, being rarely the same at a given place during two successive decades.⁵

17. Magnetic "Storms."—Magnetic storms are disturbances of the magnetic needle, which prevail with great frequency at intervals of about eleven years.⁶ During such a storm, or disturbance, the needle is subject to irregular oscillations, and is at times in a constant tremor.

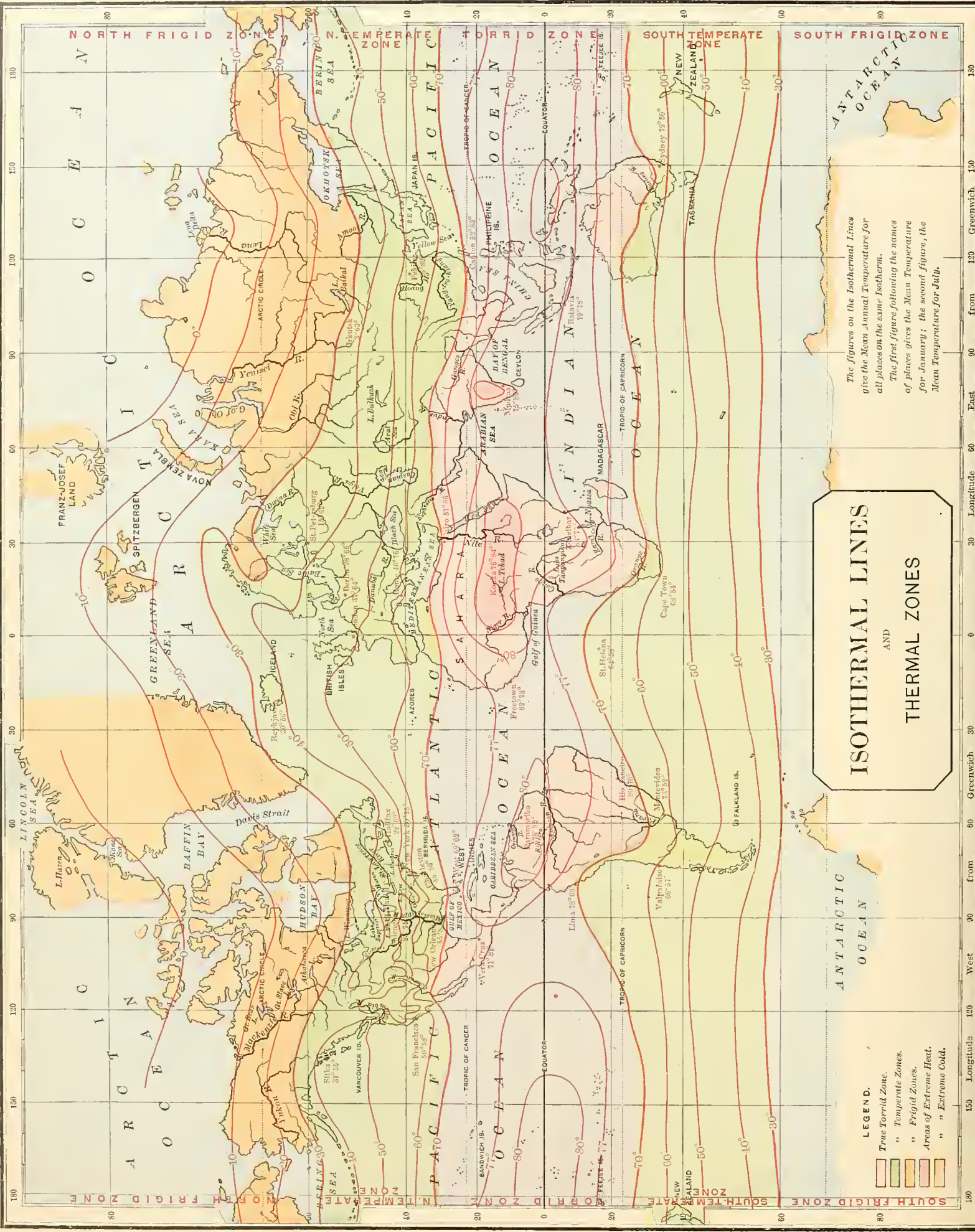
The cause of these disturbances is not known. They are, however, closely associated with the spots which at times are visible on the sun's surface. These spots are greatest in frequency at intervals of about eleven years. Magnetic storms are most frequent at times when sun-spots are visible, and they rarely occur at other times.⁷

18. Periodic Variations.—The compass-needle is also subject to daily and probably to monthly and yearly variations. These are undoubtedly due to the influence of the sun and the moon. The deviations of the needle are very slight, and cannot readily be detected in an ordinary compass.

the past three hundred years. In 1580 the variation was $11^\circ 20'$ east of north. Since that time it has gradually changed to $22^\circ 10'$ west of north.

⁶ A magnetic storm has nothing in common with the ordinary storm. It may occur in a calm and cloudless day, with no indication except the violent motion of the compass-needle. In 1882 a violent magnetic storm was registered simultaneously at the observatories of Kew in England and Los Angeles in California. It was also recorded by Lieutenant Ray at Point Barrow, Alaska, and by Lieutenant Greely at Lady Franklin Bay.

⁷ Magnetic observatories have been established in various localities for the purpose of observing the changes and variations of the magnetic needle. In order to obtain a continuous record, each magnet carries a small mirror, which reflects a minute spot of light on a revolving cylinder covered with photographic paper. By this means an irregular black line is photographed on the paper. The deviation of this line from a straight line shows the variations in direction during a period of twenty-four hours. In a similar manner a record of magnetic declination is also obtained.



The figures on the Isothermal Lines give the Mean Annual Temperature for all places on the same Isotherm.

The first figure following the names of places gives the Mean Temperature for January; the second figure, the Mean Temperature for July.

ISOTHERMAL LINES AND THERMAL ZONES

- LEGEND.**
- True Torrid Zone.
 - Temperate Zones.
 - Frigid Zones.
 - Areas of Extreme Heat.
 - " " Extreme Cold.

REVIEW AND MAP QUESTIONS ON METEOROLOGY.

GENERAL QUESTIONS.

What is Meteorology?

What is the atmosphere? What is its constitution?

State what is said of its tension. Of its density. Of its temperature. Of its height.

THE ATMOSPHERE.

How is the atmosphere warmed? How is this warmth measured?

What is wind? How does it, for the most part, originate?

Explain how a difference in the temperature of contiguous regions can produce winds.

How are winds classified?

Describe the trade-winds, their origin, limits, and deflections.

Show on the map (page 88) the extent of the trade-winds.

Describe the zones of calms.

Point out on the map their respective positions.

Describe the upper and lower westerly winds, and give illustrations.

Show on the map the regions where westerly winds prevail.

What is said of the prevalence and origin of monsoons?

Point out on the map the ranges of the monsoons in the Pacific and Indian Oceans, and their seasons.

Describe from the map the winds of the western coast of Africa.

What are land and sea breezes? Describe and explain them.

What are Etesian winds? What are the Northerers?

Give an account of variable winds.

Point out on the map the districts of hot and dry winds. Of cold winds.

What are cyclones? Describe them.

How do they originate?

To what do they owe their great force?

Explain the use of storm-cards.

What are tornadoes, and how do they differ from cyclones?

What is the funnel-cloud of the tornado?

What are waterspouts?

How do ordinary storms resemble cyclones?

Explain from the cuts on page 71 the direction of rotation and the tracks of cyclones in the Northern and Southern Hemispheres.

Where is the region of typhoons, and when do they prevail?

What advantages have resulted from the study of winds, tides, and ocean-currents?

Point out on the map the sailing routes from the United States to Europe. From San Francisco to Australia.

RAIN.

What is said respecting the moisture of the atmosphere?

How is rain caused?

What is said of the distribution of rain in latitudes?

Show from the Rain Map that this is the general law.

How do maritime and inland regions in the same latitude compare with respect to their annual rain-fall?

Show from the map that more rain falls yearly upon the western coasts of the two continents than upon the eastern.

Where is the greatest annual rain-fall?

Name the places where the annual rain-fall exceeds 225 inches. Where it ranges between 100 and 50 inches. Where it falls below 50 inches.

Why is the year here divided into the dry and rainy seasons?

Trace on the map the rainless districts of the globe.

Show on the map the regions where the rains are almost constant.

What is the annual rain-fall of the globe?

What are fogs and mists? How do they originate?

Where are fogs most prevalent?

What are clouds? How are they caused?

What is said of their height and thickness? How are they classified?

What is dew? What is said of its distribution?

Explain why dew may form on one evening and not on another equally cold

What is frost? How is it caused?

What is snow? Describe the snow-flake.

What is said of the distribution of snow? What is the snow-line?

What is hail? Describe the hailstone.

Describe the Alpine snow-fields and avalanches.

Describe glaciers, their extent, formation, structure, color, and motion.

What are moraines? Crevasses?

Describe the formation of icebergs.

What is said respecting the distribution of atmospheric moisture?

CLIMATE.

What is meant by the climate of a country?

By what are the temperature and moisture of a region modified?

Explain the effect of latitude. Of height above the sea-level.

Of the position and direction of mountain-chains, and of table-lands.

What is said respecting regions near to, or remote from, the sea-coast?

How is climate affected by prevailing winds?

Explain the effect of ocean-currents.

How is climate affected by the nature of the soil?

What are isotherms? and what is said respecting them?

Why do the isotherms extend farther to the north on the western than on the eastern coasts of the continents?

What is meant by the warm equator?

What are the zones of climate? How are they characterized?

Give an account of the hot zone, and name the countries included within it.

Describe in like manner the warm, temperate, cold, and frigid zones.

What countries possess a temperate climate?

OPTICAL AND LUMINOUS PHENOMENA.

Mention the optical phenomena of the atmosphere.

Give a description and explanation of each, and cite the illustrations.

What are the luminous phenomena?

Give an account of meteorites and shooting stars, and the theories respecting them. What is said of the ignis-fatuus?

ELECTRICITY.

What is said of electricity? Of atmospheric electricity? Describe the various phenomena.

State what is said of the Aurora Borealis.

What are the phenomena of the magnetic needle?

What is magnetic declination? Inclination?

What is said of its variation in direction from the geographical meridian?



A TROPICAL FOREST.

PART SIX.

LIFE ON THE GLOBE, AND ITS DISTRIBUTION.

CHAPTER I.

GEOGRAPHICAL BOTANY.

1. **Vegetation** extends all over the globe, existing under the most diversified conditions of heat, light, and moisture. In equatorial and tropical regions, wherever moisture abounds, it flourishes in unrivalled luxuriance.

Passing from equatorial to temperate climes, the forms of vegetation are entirely changed. The forest no longer consists of evergreens; but in their place are the oak, ash, maple, birch, chestnut, elm, beech, and walnut, which shed their foliage at the approach of winter. Here fruit-trees and the vine abound. The reed-like grasses of the tropics give place to a soft and tender herbage, and abundant harvests of grain are gathered from the well-tilled soil.

Advancing to higher latitudes, forests of fir, pine, and birch clothe the mountain-sides; but many kinds of trees and grains have disappeared.

In the polar regions there are no forests; but low flowering annuals, such as the saxifrages, gentians, and chickweed, spring up and blossom with wonderful rapidity during the brief Arctic summer. In the coldest latitudes, only lichens and mosses thrive in the frozen soil.

¹ But exceeding all other vegetable forms in grandeur are the giant sequoias, or "redwoods," of California. Several groves of these trees are found along the western slope of the Sierra Nevada Mountains. One of these trees measured 322 feet in length, and 95 feet in circumference. Another towers to the height of 350 feet, and measures 97 feet in circum-

2. **Divisions.**—The forms of vegetable life are comprised by botanists under the divisions of Phanerogams, or flowering plants, and Cryptogams, or flowerless plants. The former are classified as Exogens and Endogens.

Exogenous Plants are those whose stems grow by additions *from without*, as in the case of the oak, where successive rings of wood form beneath the bark year by year. The exogens comprise the forest trees and most of the flowering shrubs and herbs.¹

Endogenous Plants increase their stems by additions from *within*. They embrace such forms of vegetation as the palm, plantain, sugar-cane, the grasses, and all the grain-yielding plants, and are more distinguished for their usefulness than for their beauty. The principal endogens are the palms, which include the grasses.

The Cryptogams are widely diffused, and embrace the ferns, mosses, lichens, sea-weeds, and fungi. The ferns are extensively spread over the globe, but are most perfectly developed in tropical regions.

Different species of plants require different conditions of light, heat, and moisture for their development, and each region is thus characterized by its peculiar type of vegetation. Physiologists have therefore divided the flora of the globe into different zones, each distinguished by its prevailing forms of vegetable life.

3. **Zones of Vegetation in Regard to Latitude.**—The Northern and Southern Hemispheres may be divided into *botanical zones*, each characterized by the peculiar forms of vegetation which there flourish best.

On each side of the equator is the zone of *palms* and *spices*, bounded by the isotherm of 78°. Northward, the isotherm of

ference. A third, which has fallen, is estimated to have been 400 feet high, and has a circumference of 110 feet. A man on horseback can ride the whole distance through the hollow of the trunk. The stump of another has been hewn and planed to a level surface, forming a level floor thirty feet in diameter.

68° limits the zone of the *sugar-cane* and *coffee-tree*. The isotherm of 59° is the polar limit of the *orange*, *olive*, and *fig*. The zone of the *vine* comes next, limited by the isotherm of 50°. The isotherm of 41° is the northern limit of the *grains*. To this



CACTUS-PLANTS.

succeeds the zone of *firs*, *pinces*, and *birch*, whose northern boundary is the isotherm of 32°. The region of *shrubs*, *mosses*, *lichens*, and *fungi* surrounds the north pole. The zones of the Southern Hemisphere lie between the same isotherms as those of the Northern Hemisphere.

4. **Zones of Vegetation in Respect to Altitude.**—The high mountains of the tropical regions near the equator, sinking in temperature from base to summit, present the same variety of climate that exists between the equator and the poles, and are marked by similar flora.

5. **Diffusion of Plants.**—Every species of plant requires certain physical conditions for its growth and perfection, and they will thrive in those localities only where such conditions are fulfilled.¹

Most species are regarded as indigenous to a particular locality, and thence distributed by various agencies.

Winds, rivers, ocean-currents, birds, and beasts are active agents in the dispersion of plants. Many species of plants indigenous to Africa, in the vicinity of the Congo River, are found on the shores of Guiana and Brazil, their seeds having been borne across the ocean by the Equatorial Current. The seeds of certain tropical plants are carried by the Gulf Stream from the West Indies to the coasts of Scotland.

Man especially contributes to their diffusion, stimulated by the desire to add to his comforts and luxuries. The various

¹ Some plants are confined to one hemisphere. It is stated by Petermann that more than three hundred varieties of heath grow within a narrow broken belt stretching from high northern latitudes of the Eastern Continent as far as the Cape of Good Hope, while not a solitary species is indigenous to America. Only a single native species of the peony has been found in the Western Continent, which, however, is rich in the various species of cactus, a plant unknown to the Eastern Hemisphere. This remarkable plant is confined almost exclusively to Mexico and the southwestern part of the United States.

² The banana is exceedingly productive; for, according to Humboldt,

grains have been spread over nearly the whole surface of the earth by his agency.

The Romans introduced most of the finer European fruit-trees from Africa and from Asia. Most of these, in turn, have been transplanted to the new world.

FOOD-PLANTS.

6. **Tropical Climes.**—With the exception of rice, the food-plants of tropical regions are, for the greater part, fruits which are rich in sugar and starch, but deficient in acids. Most of them are included among the palms.

Rice belongs to the tropical regions, but is widely cultivated in warm, moist lowlands of other latitudes. It is the chief food in Eastern and Southern Asia. It is cultivated also in the West Indies, Brazil, and the Southern United States. Rice is thought to be native to Madagascar. It probably supports a greater number of the human race than any other plant.

Dhurra is a kind of grain extensively cultivated in India, Egypt, and the interior of Africa. It yields a beautiful white flour, as nutritious as that of wheat.

The Banana² is native to the southern part of Asia. It is a beautiful plant, having leaves six feet long, from the bases of which hang the clusters of fruit.

The Yam, or sweet potato, is a slender vine, having large tubers like those of the common potato. It is cultivated in the East and the West Indies, in Africa, and in the United States.



SEQUOIAS, OR MAMMOTH REDWOODS, OF CALIFORNIA.

The Date-Palm is native to Northern Africa. It grows wild upon the northern slopes of the Atlas Mountains, and yields the date, the chief article of food of the dwellers in the desert.³

while a thousand square feet of soil will produce only 38 pounds of wheat, or 462 pounds of potatoes, it will yield 4000 pounds of bananas, and within a shorter time.

³ So abundant are these trees in this region that it is called Beled-el-Jerid, or the "land of dates," and the date itself is termed the "bread of the desert." In Egypt and Arabia it constitutes a large portion of the food of the inhabitants, and among the oases of Fezzan nineteen-twentieths of the population live upon it for nine months of the year. A single date-palm produces, on an average, from one hundred and fifty to two hundred pounds of fruit, and continues to bear for more than two hundred years.

The Cocoa-Palm is valuable not only for the food it yields, but also for its timber, fibre, and foliage. It thrives throughout the tropical countries of the Eastern Continent, and abounds in the Indian Archipelago, in South America, and in the islands of the Pacific Ocean.¹

The Bread-Fruit Tree is a native of the Indian Archipelago and of the South Sea Islands. It is likewise found in Southern Asia, the West Indies, and Brazil.

The pulp of the fruit when cooked is soft and mealy, resembling in color and taste fine sponge-biscuit. It is a wholesome and delicate substitute for bread, and is very nutritious. The bread-fruit tree has never been found wild.

The Fig is an extensive article of food in many countries. Barley-bread and dried figs are now the ordinary food of the lower classes in



COCOA-PALM.

Greece and the adjacent islands. In a perfectly dry state the fig is about as nutritious as rice.

The Sago-Palm forms large forests in the Molucca Islands. The nutritive matter is contained in the pith of the tree, and is extracted by rubbing the pith to powder and then washing it with water upon a sieve. The sago settles upon the bottom of the vessel receiving the water.

The Manioc, or cassava, is a shrub having fleshy roots. It is native to Brazil and the west coast of Africa. The roots of the manioc contain a poisonous juice, together with a great amount of starch. The latter is obtained by grinding the roots and washing the pulp, as in the preparation of sago. Tapioca consists of the finest and purest portions of the cassava.

The Principal Fruits of the equatorial regions are the orange, lemon, and citron. The pine-apple, mango, and many others, afford abundant supplies of refreshing fruit in the climes where it is most needed.

7. Temperate Climes.—In the temperate climes, grains, for the greater part, constitute the staple articles of food.

¹ The kernel of the nut yields nutritious food and useful oil, its milk is a cool and refreshing beverage, and the fibres of its enclosing husk are twisted into ropes. The trunk is used for timber, the leaves are employed for thatching houses and woven into mats and baskets, and the shells are

Wheat, the chief of grains, has been cultivated from time immemorial. It flourishes luxuriantly in the temperate climes of both hemispheres, and on the mountain-heights of the torrid zone at the altitude of 10,000 feet. It appears to have originated in Tartary, and thence to have spread westward.

Immense quantities are now produced in Europe and in the United States. The geographical northern limit of wheat in Europe is about the 64th degree of north latitude, and in North America it is cultivated as high as the 54th degree of north latitude.

Rye was first known to the Persians. It is largely cultivated in Germany, Sweden, Norway, and Russia, and furnishes bread for nearly one-third of the population of Europe. Its northern limit is about the 67th parallel.

Barley resembles wheat, both in composition and in nutritive qualities. This grain is probably indigenous to Tartary. It was introduced into Germany by the Romans.

Oats are supposed to be native to the Caucasus Mountains. This grain is very nutritious, and, though principally employed as food for horses, it is a staple article of diet in Scotland and North Germany.

Maize, or Indian corn, is probably indigenous to the New World. It has been found wild in the woods of Brazil; and ears of maize have been discovered in the tombs of the ancient Peruvians. From the New World it was carried to the Eastern Continent, being first introduced into Europe, whence it rapidly extended over Asia.

Buckwheat is probably a native of Northwestern China, and thence, extending westward, was at length introduced into Europe. It is abundantly cultivated in Siberia and on the steppes of Central Asia. Buckwheat flour is about as nutritious as that of wheat.

The Potato is a native of Chili and Peru, and was introduced into Europe in the sixteenth century. It is now widely diffused, being cultivated in Europe from Iceland to Greece, and throughout most of Southern and Eastern Asia.

The Chief Fruits of the temperate zones are the grape, apple, pear, peach, cherry, quince, plum, and apricot.

The grape grows wild in Tartary and in North America. It probably extended at a very early period over all the regions then occupied by man; and, as civilization advanced, it was at length disseminated throughout Southern and Central Europe and the United States.



PEPPER-PLANT.

formed into drinking-cups. The tree grows to a height of eighty feet, and is crowned with a tuft of twenty or thirty leaves, each of which is six or seven yards in length. Between these, at their bases, are branches of tendrils on which the fruit grows.

8. **Plants yielding Sugar.**—The principal plants of this character, including the sugar-cane and the sorghum-cane, are native to tropical regions. They are extensively cultivated, however, in temperate latitudes.

The Sugar-Cane, which ranks foremost among plants of this kind, is probably a native of the tropical climes, having originated in the East. It has been cultivated in China and the Pacific Isles from very remote times. Through Arabia it came into the south of Europe and to the Canary Isles. It was carried from the latter region to St. Domingo by the Spaniards, and from this island it has since spread throughout tropical America.

The Date-Palm affords a juice which yields a brownish sugar extensively manufactured in the South Sea Islands.

The Sugar-Maple, which abounds in the Northern United States and in the Dominion of Canada, affords an excellent sugar, which is extracted from its sap.

9. **Plants producing Beverages.**—The plants used for this purpose are not confined to any particular locality or botanical division. They are found in both tropical and temperate regions.

The Tea-Plant is an evergreen shrub about six feet high. It is regarded as indigenous to China and Japan. The plant flourishes as far as the 33d degree of north latitude, but the finest tea grows between the 27th and 31st parallels, on the low ranges of the Peling Mountains. The picking of the leaves begins in the fourth or fifth year of the plant's growth, and is seldom continued beyond the tenth or twelfth.

The use of tea was not general in China till after A.D. 600; but it is now the favorite beverage of all classes. Tea was first brought to Europe by the Dutch in 1610, and into England about the year 1650.

Maté, or Paraguay Tea, is prepared from the dried leaves of the Brazilian holly, which grows spontaneously in the forests of South America. It has been employed as a beverage by the people of that country from time immemorial, and its use there is almost universal.

Coffee is the berry of a tree, native to Abyssinia, where it grows wild among the mountains. It was introduced into Arabia from Abyssinia in the fifteenth century, but was not brought to Europe before the year



TEA-PLANT.

1517. It began to be cultivated in South America in the eighteenth century.¹

Cacao is the seed of a tree indigenous to the West Indies and Central America. It grows wild in Mexico, and forms entire forests in Guiana. When the Spaniards conquered Mexico they

¹ About one hundred and forty years ago the Dutch carried the coffee-plant to Batavia, whence it has extended over Southern India and the ad-

jacent isles. The amount of coffee now annually produced throughout the globe has been estimated at 600,000,000 pounds.

found the beverage prepared from the cacao in universal use. To this preparation the natives give the name of *chocolate*.

10. **Plants yielding Spices.**—All of the spices are native to tropical regions, and by far the greater part come from the islands of Malaysia and the neighboring coasts.

The Pepper-Plant embraces several hundred species, all of which flourish in the hottest regions of the globe. Black pepper consists of the berries of a climbing, perennial plant, and grows in clusters around a long stem. The plant is a native of Malabar, and is cultivated in southwestern Asia, Borneo, Java, and the adjacent isles.



COFFEE-PLANT.

Capsicum, or Cayenne pepper, is produced by a plant of an entirely different order (the *Solanaceae*), and grows in pods. It is extensively used both in the East and the West Indies and also in South America.

The Clove-Tree is an evergreen, belonging to the myrtle tribe. It is a native of the Moluccas and other islands of the Indian Archipelago, whence it has been disseminated throughout Asia and the West Indies. The spice consists of the dried flower-buds of the tree. Allspice, or pimento, is also the produce of a species of myrtle.

The Nutmeg is the seed of a juicy fruit similar in appearance to the apricot, and is produced by an evergreen tree of the laurel family. It is cultivated in Sumatra and the West Indies. Mace is the husk of the nutmeg.

Cinnamon is the inner bark of the twigs of a species of laurel. It flourishes in Malabar and in the isles of the Indian Archipelago, and has been transported to the West Indies, Brazil, and other parts of South America.

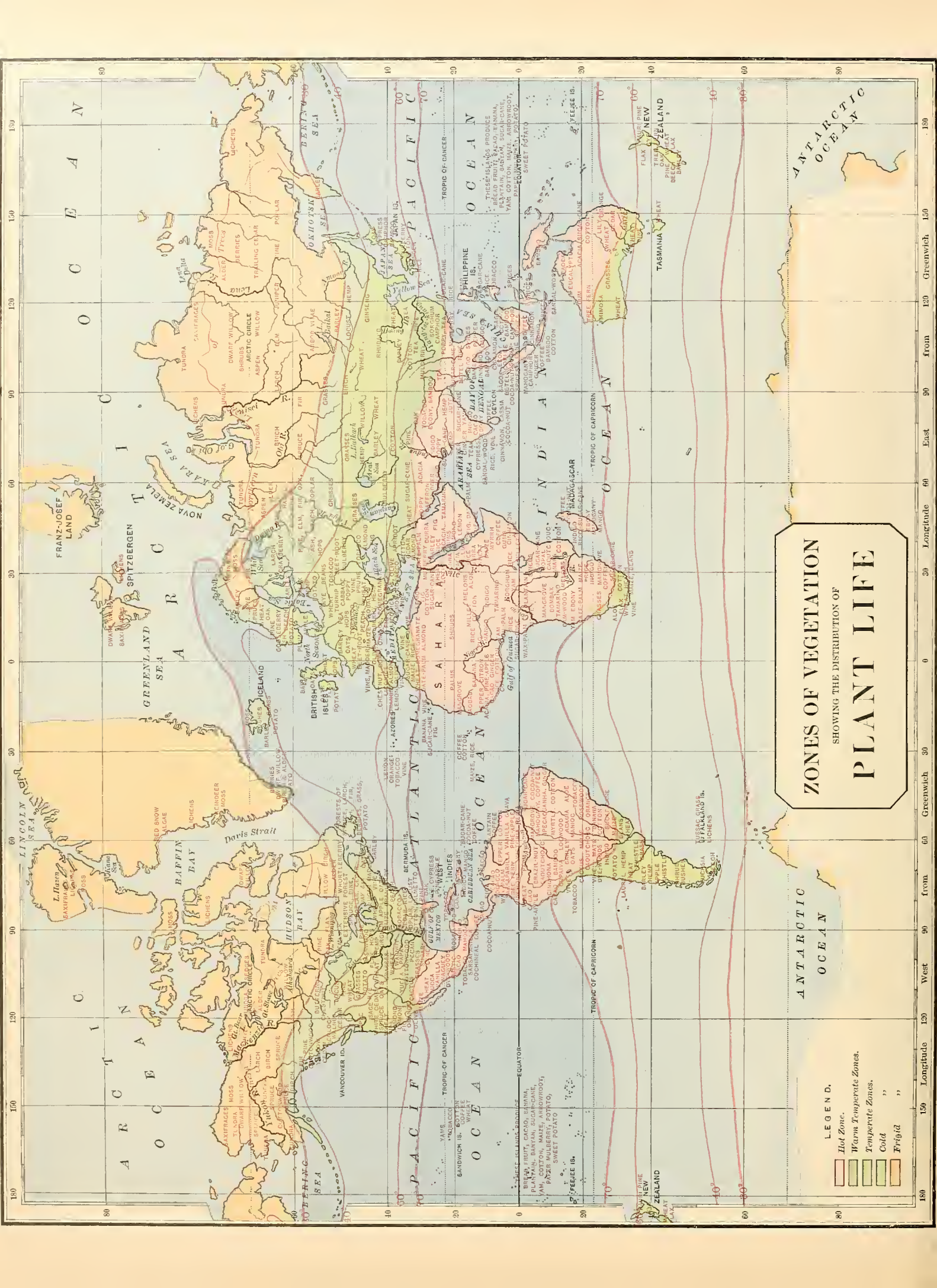
The finest cinnamon is obtained from the shoots that spring up from the roots of the trees. Cassia is obtained from another but inferior species of the laurel, which grows in Eastern China and in the Asiatic isles.

MEDICINAL PLANTS.

11. **The Cinchona-Tree**, of which there are nineteen species, grows upon the slopes of the South American mountains, between the altitudes of 5000 and 8000 feet. From its bark is extracted the medicine known as quinine. This species of plant also furnishes ipecacuanha, the powdered root of a creeping plant that grows in the forests of Brazil.

Opium is found in the milky juice of the poppy. It is obtained

adjacent isles. The amount of coffee now annually produced throughout the globe has been estimated at 600,000,000 pounds.



ZONES OF VEGETATION
SHOWING THE DISTRIBUTION OF
PLANT LIFE

- LEGEND.
- Hot Zone.
 - Warm Temperate Zones.
 - Temperate Zones.
 - Cold
 - Frigid

by making incisions in the seed-vessels. The juice exudes, and, after being hardened by exposure to the atmosphere, is scraped off for use. The best opium comes from India. The principal extractive substances are morphine and narcotine.



PALMS, AND OTHER GRASSES.

Rhubarb is the root of a plant that grows wild upon a chain of mountains near the frontiers of China; and nearly all the rhubarb of commerce is said to come from this region.

The Tobacco-Plant is considered to be indigenous to tropical America. In 1492 Columbus found the Indians of Cuba smoking leaves of the tobacco-plant. In 1568 it was brought to England by Sir Francis Drake. It has since become most widely disseminated.

Indian Hemp affords various narcotic preparations, which have been extensively used in both hemispheres from the earliest ages. Hasheesh, the form in which it is most commonly used, is prepared from hemp. It is abundant in the tropical forests of Asia, Africa, and Brazil.¹

PLANTS OF ECONOMIC USE.

12. The Cotton-Plant belongs to the mallow family, and grows spontaneously within the torrid zone throughout Asia, Africa, and America. It is, however, cultivated to an immense extent beyond this region, and, under the varying conditions of soil and climate, assumes the form of a tree, of a shrub, and of an herb.

The cotton consists of a mass of soft fibres, which surround the seeds of the plant. It has been manufactured in India from the remotest antiquity, and is a staple product of the United States.

Cotton-Seed-Oil is obtained by pressure from the seeds of the cotton plant. It is much used as a substitute for olive oil, to which it is but slightly inferior.

The Flax-Plant is but little affected by differences of soil and climate, and flourishes alike in the cold and temperate regions of Europe, throughout the New World, and in Asia and Africa. From the fibrous bark that surrounds its stem the thread is obtained which is used for making linen.² Linseed-Oil

is expressed from the seeds of the flax-plant, and is used chiefly in the manufacture of paints.

Hemp (*Cannabis sativa*) is cultivated throughout Europe, especially in Russia, and to some extent in the United States. The fibrous bark furnishes the hemp of commerce, which is wrought into ropes and cables, and cloths of varied texture.

The Olive is native to the hot regions of Asia, whence it has been disseminated throughout the south of Europe and the north of Africa. It is also cultivated in the southern part of the United States. The oil extracted from the seeds of the fruit is largely employed in the arts.

Palm-Oil is extracted from the kernels of the fruit of two species of palm which grow in several regions in Africa, but abound especially in Senegal. It is much used in the manufacture of soap and perfumery.

Oil of Turpentine exists, in combination with resin, in the trees of the pine and fir family. When incisions are made in the tree, the turpentine flows from the special cells of the wood in which it is secreted. The oil is separated from the resin by distillation. The same kind of trees yields also tar and pitch.

Gum-Arabic is derived from a species of acacia which abounds throughout Arabia, Central Africa, and Mexico. The gum exudes spontaneously from the trunk and branches of the tree.

Gum-Copal is obtained from a species of sumach, which comes to perfection only in tropical climates. This gum, from its hardness and transparency, is much used as a varnish.

Caoutchouc, or India-rubber, is contained abundantly in the juice of several species of trees that grow in tropical regions. By making incisions in the bark, the juice exudes, thickening, by exposure to the air, into caoutchouc. Dissolved in naphtha, it is spread like a varnish over cloths, rendering them impervious to water. Combined with sulphur, it forms *vulcanized rubber*.

Indigo is obtained from several different species of plants, of which some grow in almost every part of the torrid zone. The coloring-matter is extracted by fermentation, and is the most



GATHERING CAOUTCHOUC.

beautiful and valuable of all the blue dyes. British India furnishes nearly three-fourths of all the indigo imported into Europe. It has been raised to some extent in the Southern States.

¹ The effect of this narcotic is to produce cheerfulness and an increase of appetite, when moderately used; but if taken to excess it causes delirium and catalepsy. Its continued use is often fatal.

² Flax was grown in Egypt nearly four thousand years ago; and the microscope proves that the cloths in which the Egyptian mummies are wrapped are linen fabrics.



IMPERIAL EAGLE.

WHALE-FISHERY.

BOA.—TIGER.

CHAPTER II.

GEOGRAPHICAL ZOOLOGY.

1. **Geographical Zoology** treats of the general divisions of the animal kingdom, and of its distribution and diffusion over the surface of the earth.

2. **Distribution.**—As animal life is intimately connected with vegetable existence, it is evident that both are governed by the same general laws of distribution. The condition of animals is influenced by the nature of the climate to which they are subjected, and of the food which they eat.

Distinct species are more or less confined each within its own geographical region; and if transported beyond this, the animal lives or dies, according to its power to adapt itself to the new conditions of existence. The animal life of any particular region is termed its *fauna*.

The torrid zone is the home of the fiercest and largest animals. Here are found the lion, tiger, rhinoceros, elephant, and the most poisonous reptiles. Birds of brilliant plumage and insects of dazzling hue are found also in this zone.

The fauna of the tropical climes is as varied as the flora. Not only are the species of animals more numerous than in other latitudes, but the largest forms and the most perfect development are here attained.

Animal life is so abundant in the moist tropical regions that among the various species there is a constant battle for life, in which only the stronger individuals survive.

The temperate climes are the abode of the domesticated and useful animals, such as the horse, ox, sheep, and dog. Reptiles and beasts of prey are less numerous and powerful than in the

equatorial regions. Typical species of birds and beasts, such as the eagle, turkey, and pheasant, and the wolf, fox, beaver, and kangaroo, here abound. In this zone the species are smaller than those native to the tropical climes. They are also inferior to them in beauty.

The polar fauna comprises few species. The birds and beasts are dull and sombre in hue, or else of a snowy white. The reindeer, polar bear, sable, and ermine, are peculiar to this region; reptiles are unknown, and the numerous sea-fowls migrate hither from the temperate regions.

At different heights above the sea, different faunas are likewise found. At the bases of the lofty mountains of the globe the animals peculiar to the respective latitudes of these regions appear; but as we ascend, peculiar types of animal life characterize the varying altitudes.¹

On land, the number of species decreases with the increase of latitude; but in the ocean this law is partly reversed. In the tropical seas marine life is distinguished for its brilliant colors. In the seas of the higher latitudes life has less variety of species, but the individuals are far more numerous; for it is only in their cool waters that the herring, cod, mackerel, haddock, shad, and salmon, and other fishes prized for food, are developed in such vast numbers, and it is to these seas that the true whale is confined.

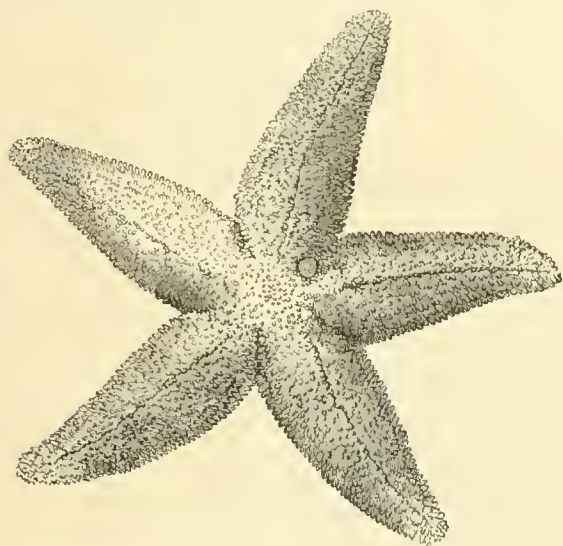
The dispersion of animals from the region where they have originated has been effected by their own powers of motion, by the agency of man, and by the currents of the air and ocean.² The wild duck and wild pigeon fly from four hundred to five hundred miles a day.

Insects and land-birds, either driven by the winds or journeying of their own accord, have alighted on the spars of vessels far out of sight of land. The polar bear has frequently been con-

¹ Thus, on the Alps the chamois and the steinbok have their home between the upper limit of trees and the snow-line; and the llama dwells in a similar region among the rocky heights of the Andes. In Asia the yak thrives amid the snows of the Himalayas even during the winter, and retreats in the heat of summer to the snowy regions.

² A live boa-constrictor was once found on the island of St. Vincent, coiled round the trunk of a cedar-tree, which had probably been carried out to sea by the flood of one of the great South American rivers and borne by the ocean-currents to the island. Similar occurrences have been noticed in the vicinity of the East Indian coast.

veyed on floating ice from Greenland to Iceland; and wolves and foxes have been found far from land on the drifting ice-field. In these various ways has animal life been diffused from the main land to adjacent isles, and from one island-group to another.



STAR-FISH.

The diffusion of animals has been greatly promoted by man, who, in all his migrations, has carried with him those animals which are useful for labor, and which contribute to his sustenance and comfort.

Thus, the ox, horse, sheep, and pig have accompanied the march of civilization. The vast herds of cattle and wild horses

that roam over the plains of South America are the descendants of European breeds. In Australia, the sheep introduced by the colonists have multiplied to such an extent that wool has become an important article of export.¹

On the other hand, man has greatly restricted the domain of both dangerous and useful animals. Thus, the Asiatic lion, which once roamed throughout Asia Minor, is now confined to

the regions beyond the Euphrates. The bear, wolf, and beaver, which centuries ago abounded in Great Britain, are now never met with there.

In the United States, the bison has retreated from the Atlantic States, and there is probably not a single herd south of the Dominion of Canada. The beaver and other fur-bearing animals

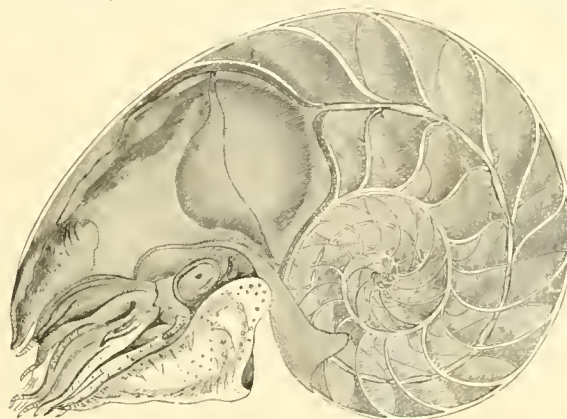
¹ Other species of animals have also followed man of their own accord, such as the rat and mouse. The brown rat of Persia, which was introduced into Europe about the year 1727, has been conveyed, in the holds of ships, to almost every part of the world.

^{2 3 4 5} From the Latin words *mollis*, "soft;" *radius*, a "ray;" *articulus*, a "joint;" and *verto*, to "turn."

⁶ The searching investigations of naturalists have shown that the infusoria are most widely diffused over the globe; that they abound in all waters, and exist in the fluids and tissues of animal and vegetable bodies. They are extremely tenacious of life, being found alive in the floating ice

have also withdrawn from their old abodes, and the hunter now seeks them in the deeper recesses of the forests.

Such has been the unremitted persecution of the whale, in the great demand for oil, that but few can now be found, and in this country the seaports formerly supported by this fishery have fallen into decay.



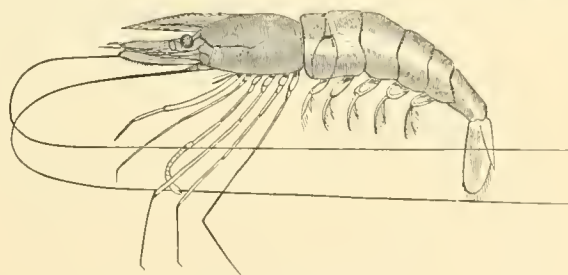
NAUTILUS.

3. **Classification.**—The animal kingdom is divided into four branches—Mollusks,² Radiates,³ Articulates,⁴ and Vertebrates.⁵

4. **Mollusks.**—These animals are of a soft texture, without any skeleton, and their bodies in most cases have the power of forming a shelly covering. To this branch, which is chiefly aquatic, belong the snail, squid, nautilus, clam, and oyster. They are commonly known as *shell-fish*.

5. **Radiates.**—Radiates have the parts of their bodies arranged in a circular manner around a centre, so as to present a radiated appearance, like the spokes of a wheel. Of this form are the well-known star-fish, and the prickly echinus, or sea-urchin. To this branch belong also the crinoids, or lily-formed animals, the umbrella-shaped medusæ, the zoophytes, or plant-animals, the coral polyp, and the infusoria.⁶

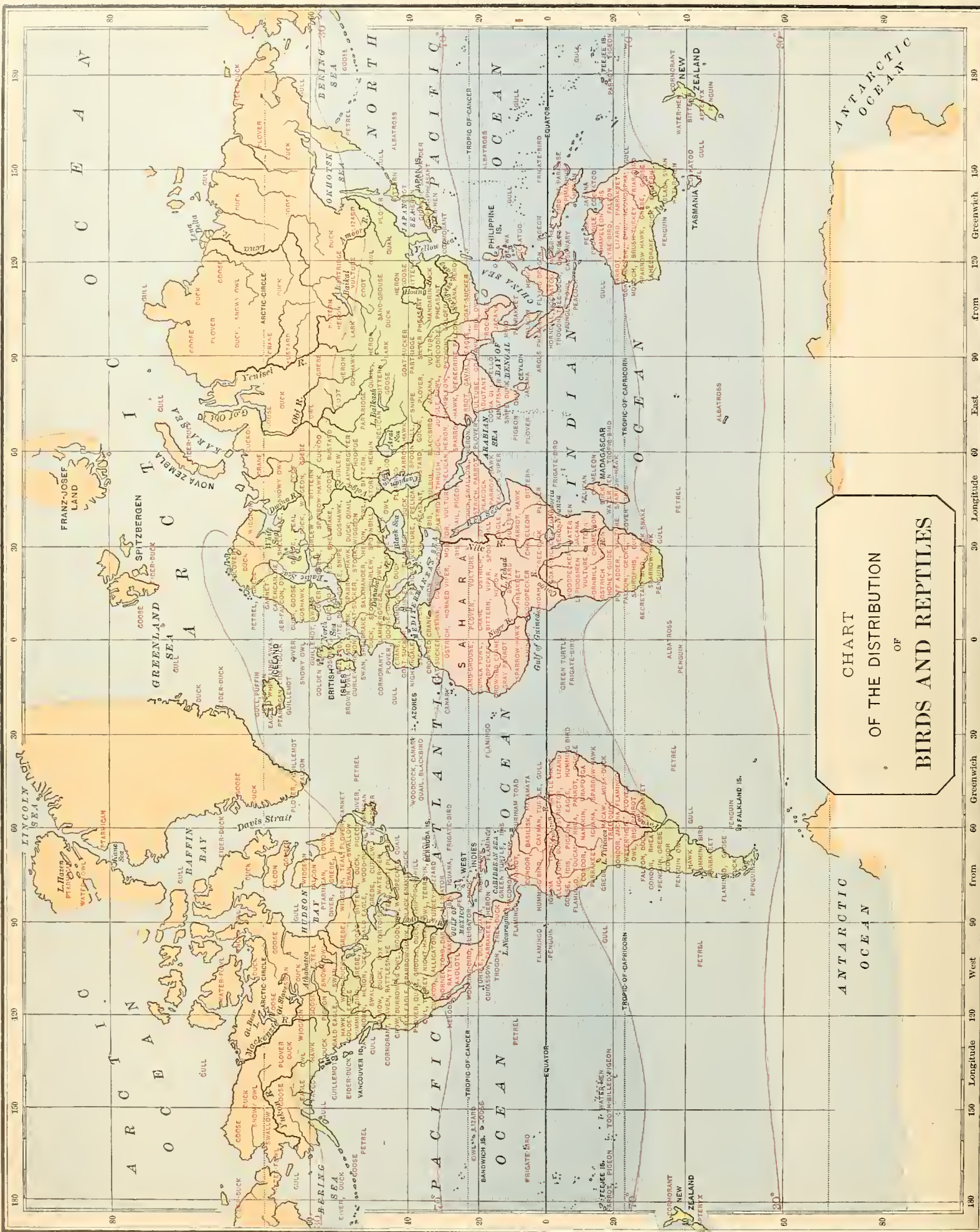
6. **Articulates.**—This branch includes those animals whose bodies are composed of joints and rings, as the lobster, crab,



COMMON SHRIMP.

shrimp, barnacle, and earthworm. It includes likewise the various forms of insect life, such as butterflies, beetles, scorpions, spiders, and locusts.

of the Arctic Ocean, while certain species retain vitality at a temperature of 212°. Many species of these organisms are encased in shells, consisting for the most part of lime and flint, which remain for ages after the animal has perished. To such an extent have the infusoria abounded that entire ranges of hills and masses of rock are found composed of these minute envelopes. Bog-iron is made up of microscopic iron shells. Forty-one thousand millions of organic forms are contained in a cubic inch of the tripoli rock of Bilin; and the cities of Richmond and Petersburg rest upon beds of marl from twelve to twenty-eight feet thick, full of curious infusorial structures. Shells of this kind have also been found in volcanic ashes.



CHAPTER III.

THE GRAND DIVISION OF VERTEBRATES.

FISHES, BATRACHIANS, AND REPTILES.

1. **Vertebrates** are distinguished by having a jointed backbone, or vertebral column. They rank the highest of all animals in their organization. They are classified as *Fishes*, *Batrachians*, *Reptiles*, *Birds*, and *Mammals*.

2. **Fishes.**—Fishes form the lowest class of vertebrates. They are cold-blooded animals, and breathe by means of gills.

The cod move in shoals of great size. The Grand Bank of Newfoundland for an extent of four hundred and fifty miles is the favorite resort of this valuable fish, and millions are caught here every year.

The herring resorts to the coasts of Western Europe, and is found along the eastern American shores as far south as the Carolinas.



ALLIGATOR.

The salmon is also migratory, going from the sea up the rivers to spawn. This fish frequents the rivers of the Pacific coast in immense numbers.

3. **Batrachians.**—Batrachians, which are also cold-blooded animals, include frogs and salamanders. They comprise more than 1000 different species.

Frogs constitute a link between the land and water animals. They are found in almost every part of the globe; one species exists near the Alpine snow-line. The tree-toad is included in this order. Salamanders differ from frogs in having tails and feet. Some species are aquatic, but others are confined to the land.

4. **Reptiles.**¹—The class of reptiles, which consists of cold-blooded animals, includes three families—the saurians, chelonians, and ophidians.

Saurians² are found throughout the tropical and temperate climes; and to this order belong crocodiles and lizards. The crocodile is found in Africa, India, and the hottest parts of America. The alligator is found in the Western Hemisphere only. It abounds in the bayous and lagoons of the Gulf States, and is so ferocious as to attack men and animals.

Chelonians³ comprise tortoises and turtles. They are distinguished from other reptiles by being enclosed within a shell. Some of the land tortoises are of great size—one species, belonging to the Galapagos Islands, attaining a weight of from five hundred to six hundred pounds.

The green turtles, so much prized for food, live in the Atlantic within the tropics. They are often six or seven feet long, and reach the weight of from six hundred to seven hundred pounds. Tortoise-shell is obtained from the hawk's-bill turtle, which is found in different parts of the Indian Ocean.

Ophidians⁴ include the various species of snakes. They are found in the torrid and the temperate zones, especially in the former. Some of the species are venomous, but the greater part are innocuous. The largest snakes are the boas and pythons.

The boas are found only on the Western, the pythons are confined to the Eastern Continent. The boa, varying from nine to fifteen feet in length, abounds in the dense forests of South America. The python is the largest of all serpents in the Eastern Continent, growing to the length of from fifteen to twenty



CONDOR.

IMPERIAL EAGLE.

PENGUIN.

feet.⁵ The boa and the python live chiefly on small quadrupeds, which they crush to death in their powerful folds, and swallow their bodies entire.

¹ From the Latin word *repto*, to "crawl."

² ³ From the Greek words *saura*, a "lizard," and *chelonē*, a "tortoise."

⁴ From the Latin word *ophis*, a "snake."

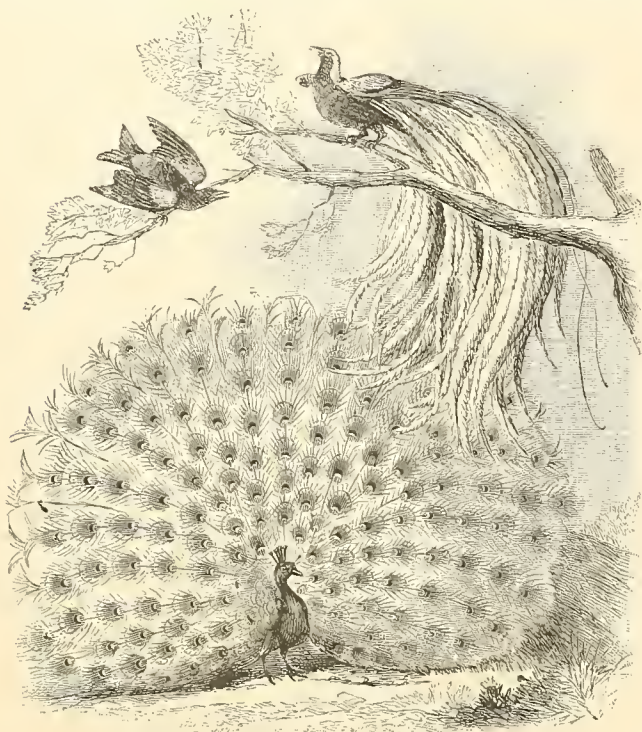
⁵ Most deadly among the poisonous snakes are the cobra de capello and the rattlesnake. The cobra is found from Malabar to Sumatra, and in some parts of Africa, and is so venomous that, on one occasion, when the tips

of the ears of a wild hog were pressed between two boards and the snake was made to bite them, though the wounded parts were cut off immediately, the animal died in a few seconds. The rattlesnake is found only in America, and is so called because the tip of its tail is formed of several loosely-jointed bones, which the animal rattles when it is aroused or irritated. Rattlesnakes are most numerous in hot, arid regions.

BIRDS.

5. **Birds** are found all over the globe. Arctic voyagers have seen them passing northward beyond the highest latitudes they themselves have been able to attain; and from the sea-level, they soar far beyond the snow-line of the loftiest equatorial mountains. Most species are confined to particular regions; but there are exceptions to this law.

A great similarity exists between the birds of the northern regions of the Eastern and Western Continents; but the birds of



THRUSH. PEACOCK. BIRD OF PARADISE.

the tropical and southern temperate zones of America are entirely different from those of the same regions of Asia, and these again are unlike those of Africa.

Many birds are migratory, passing the winter in one country and the summer in another. Of this class are geese, swallows, and pigeons. Some migrate singly, others in groups, and some in immense flocks.

The Birds of Prey include vultures, falcons, and owls. Chief among the vultures is the condor, the largest of birds. It dwells exclusively amid the Andes. Eagles live chiefly in mountainous regions. The bald eagle, the most distinguished of the species, is peculiar to North America.

The Perchers include the singing-birds, such as the lark, oriole, canary, mocking-bird, and thrush. The bird of Paradise, the kingfisher, and the beautiful group of humming-birds also belong to this group.

The birds of Paradise are inhabitants of New Guinea and the neighboring islands. Humming-birds are found only in the Western Continent.¹

The Climbers include parrots, toucans, woodpeckers and cuckoos. The latter two are most numerous in temperate regions.

¹ The humming-bird is found chiefly in tropical regions. A few species, however, live in temperate latitudes. No more than four species belong to

Parrots swarm in the tropical forests of Africa and Asia, while no fewer than forty species are natives of South America. These birds are chiefly confined to the torrid zone. Toucans are noted for their large, thin bills, and their brilliant plumage. They are indigenous to the tropical climes of South America, and abound in the dense forests of Brazil.

The Scratchers include the peacock, pheasant, quail, grouse, domestic fowl, and pigeon.

The peacock, renowned for its gorgeous plumes, belongs to Southern Asia; and two species live wild in the groves of India and Ceylon. The pheasant is also Asiatic in its origin, and is scarcely less beautiful than the peacock.

The turkey is a native of North America, and ranges from the 45th parallel to the Isthmus of Panama. It was introduced into England in 1526, and is now domesticated in all parts of the world. Pigeons belong to both the Old and the New World.

The Runners are few in number, and comprise the ostrich, cassowary, emu, and apteryx. They are birds of great size, and have comparatively short wings, which assist them in running, but are useless for flying.

The African ostrich is the largest of the species. It inhabits the deserts of Africa, and is believed to be the fleetest of all running creatures. Formerly this species extended throughout Asia Minor, Persia, and Eastern Asia, but it is now rarely found in this grand division. The ostrich is hunted for the sake of its plumes. Within a few years it has been reared in Southern California.



OSTRICHES.



APTERYX.

The cassowary, which is a native of Java, is covered with a plumage that resembles coarse hair. It runs with a bounding

North America, while in tropical South America three hundred species exist, varying from the size of a wren to that of a humble-bee.

motion, far surpassing the speed of a horse. The emu is found only in Australia. The apteryx lives only in New Zealand.

The **Waders** are noted for their stilt-like legs and long necks, by which they are enabled to wade and to obtain food in shallow



ORIOLE.

water. Such are the stork, heron, plover, snipe, and flamingo. The common stork of Europe migrates to Asia Minor, where it spends the winter.

The **Swimmers** include such birds as have comparatively short legs, webbed feet, and bodies adapted to swimming. Among them are the duck, pelican, penguin, gull, and albatross.

One of the most important is the eider-duck, so well known for the delicate down it affords. It is about twice the size of the common duck, and is found both in Europe and in America.¹ It is confined wholly to high latitudes.

The penguin is found in the high southern latitudes. Here they are seen in countless numbers upon the snow-clad islands. Gulls are found in every latitude and sea. The albatross, the largest of sea-birds, is found in all latitudes.

MAMMALS.

The mammals include those warm-blooded animals that suckle their young. To this order belong those creatures that are most useful and serviceable to man.

6. **Marsupials.**—This class embraces all such animals as the kangaroo, wombat, and opossum. They are distinguished by having a pouch, in which the females carry their young. A few marsupials are found in the New World; all the rest belong to Australia and the adjacent isles.²

7. **The Edentata.**—This class comprises the toothless ani-

¹ In the Arctic regions they breed in immense numbers on the rocky shores of the mainland and islands, the mother-bird making her nest of sea-weed and lining it with the soft down from her breast. A breeding-place visited by Dr. Kane in the Arctic Sea, and called by him Eider Island, was so thickly covered with nests that hardly a step could be taken without treading upon them.

² The kangaroo is a native of Australia, and is one of the most noted of the marsupials. Its limbs are very disproportionate, the fore-legs being short and small and the hind-legs long and powerful; on this account it is enabled to make extraordinary leaps, passing over the ground at a rapid

rate. Its young, in a rudimentary state, are nourished in a pouch attached to the mother, where they remain until they become fully developed. The opossum is peculiar to America.

8. **The Rodents.**—The rodents, or gnawing animals, comprise such animals as the squirrel, beaver, rat, and prairie-dog.

The beaver is found in the rivers of Europe and Asia from the 36th to the 67th parallel, and in America from the Ohio to the Mackenzie River.³

Rats are widely distributed, and follow man wherever he settles. When they become so numerous in any region that they cannot obtain food, they migrate of their own accord.⁴

The prairie-dog is a species of marmot, and abounds in the great prairies of the West. Prairie-dogs live in large communities, their burrows, or villages, being many square miles in extent.

9. **The Pachyderms.**—The pachyderms, or thick-skinned animals, comprise the strongest and largest quadrupeds, and nearly all the domesticated animals. Most of the families of this class are confined chiefly to the torrid zone, and delight in moist forests and jungles. Among the most noted genera included in this class are the elephant, rhinoceros, hippopotamus, horse, hog, and tapir.

The Asiatic elephant ranges through Southeastern Asia and Sumatra. The African species is smaller than the Asiatic. Its domain stretches from the northern limits of Cape Colony to the Senegal River. The elephant has been trained from the earliest



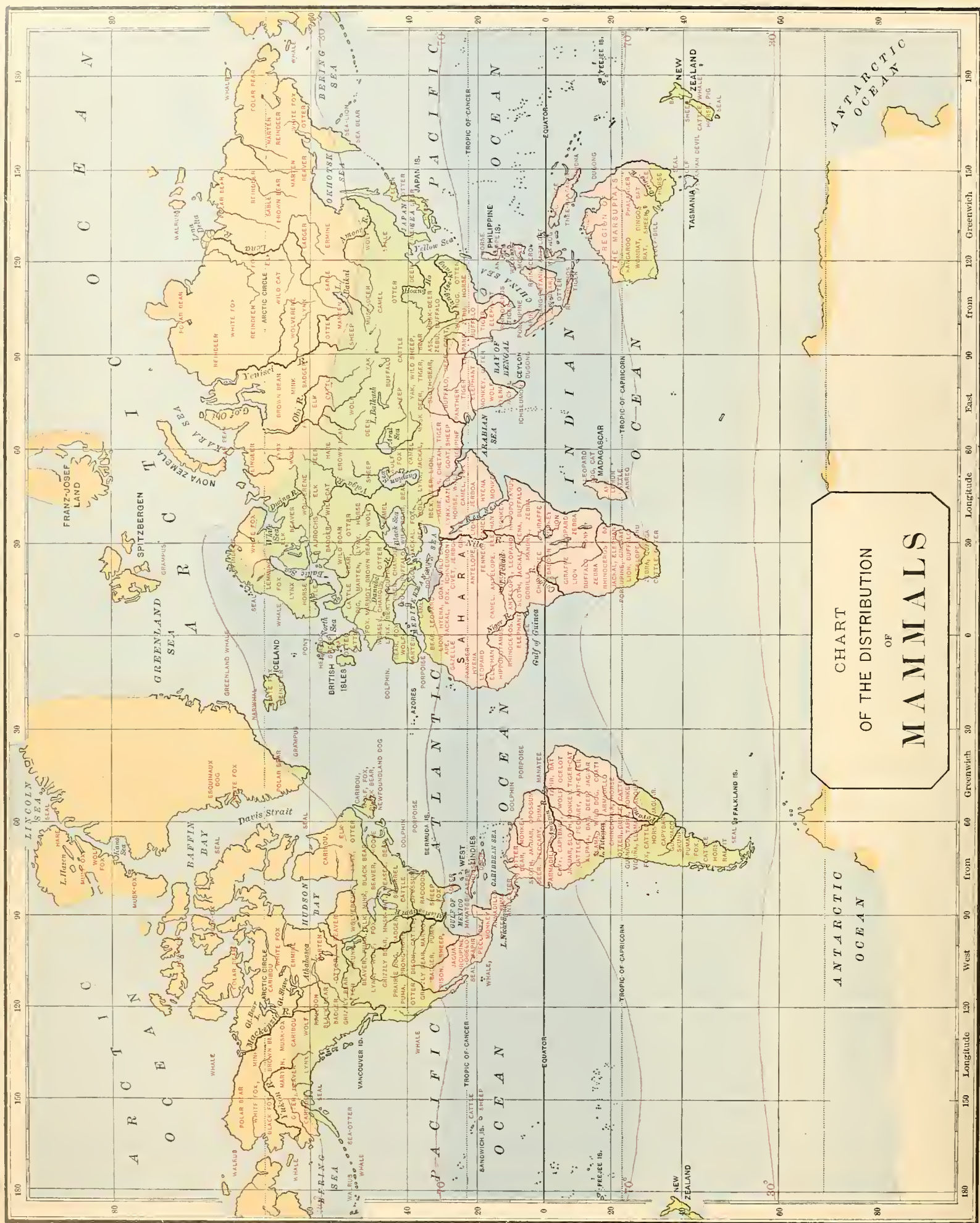
ELEPHANTS.

times for warlike and domestic purposes. It is one of the most sagacious and intelligent of animals.

rate. Its young, in a rudimentary state, are nourished in a pouch attached to the mother, where they remain until they become fully developed. The opossum is peculiar to America.

³ Beavers live in communities, and erect huts for themselves in ponds or running streams, constructing dams in the latter in order to obtain a sufficient depth of water. These dams are formed of trees, often five or six inches in diameter, which the beavers cut down with their teeth.

⁴ The lemming, a similar species, migrates for a like cause. In the spring great multitudes of them set out, travelling for hundreds of miles, and swimming the rivers that cross their path.



The rhinoceros inhabits the thick forests of Asia and Africa, its range being the same as that of the elephant.¹ It is found also in China and Java.



LION.

The hippopotamus, or river-horse, is a large, unwieldy animal, peculiar to Africa. It is there found in many of the rivers and lakes, feeding upon the herbage that grows in their beds.

The hog is the most widely diffused of all the pachyderms, and assumes the greatest variety of forms. The wild boar, which is the original stock of the common hog, ranges from the western shores of Europe to the China Sea.

The horse is found tamed in every part of the world, and, though doubtless originally wild, yet the time when it was first domesticated is so remote that its native abode is unknown. Vast herds of wild horses now roam over the highlands of Tartary and the pampas of South America. These are regarded as the descendants of domesticated animals.²

The wild ass is found in herds throughout Central Asia, migrating southward on the approach of winter.

The zebra is found only in Africa, and ranges northerly from Cape Colony to Congo, Guinea, and Abyssinia. One of this species, the quagga, though bold and fierce on its native plains, has been occasionally domesticated.

The tapir is most numerous in South America. It is found also in Sumatra, Malacca, and some of the adjacent isles. The tapir is a large animal, resembling the hog in form.

10. The Carnivora.—The carnivora, or flesh-eating animals, include animals of the most ferocious disposition. Their teeth and claws are especially adapted for tearing the flesh of the weaker animals, on which they prey. Carnivorous animals are most abundant in the torrid zone, but are by no means confined to it.

The brown bear ranges over the northern regions of the Eastern Continent from Norway to Japan. In the Western Hemisphere this species is found on the northwestern coast regions.

¹ There are seven species of the rhinoceros—three Asiatic and four African. Three of the African species have two horns; and the fourth, one.

² The wild horses of America sprang from tame horses turned loose by the Spaniards; and the herds of Tartary are supposed to have originated in a similar way. Wild horses have almost entirely disappeared from the

The black bear is found in North America, north of the 30th parallel. The grizzly bear, the strongest and most ferocious of the species, is found only within the Western Highlands of North America.

The polar bear dwells in the Arctic climes, and ranges no farther south than about the 55th parallel. It is a bold swimmer, and preys upon seals and the carcasses of whales.

The lion roams over nearly the whole of Africa, but in Asia is confined to particular parts of Arabia and Persia, to the country bordering the Euphrates, and to certain parts of India.

The tiger, which equals the lion in strength and activity, is found in Southern Asia only. The Bengal tiger is the most ferocious of the species.

The puma, or American lion, ranges from Patagonia to the Great Northern Lakes. The jaguar lives chiefly in Brazil and Paraguay. It rivals the tiger in strength and ferocity. The leopard and panther are natives of Africa and the southern parts of Asia. A species of the latter found in the mountainous regions of the Western Continent is nearly if not quite identical with the cougar, or puma. In Europe, the wild-cat is the only representative of this family.

The dog has followed man in his migrations about the earth as a faithful and attached companion, his affection continuing even under ill-treatment.³

The wolf is found in North America, throughout nearly all Europe, and in Northern Asia. The fox, which is confined to



WALRUS AND SEALS.

the same geographical limits, is represented by several varieties—the red fox of North America, the common fox of Europe, the black fox, and the Arctic fox.

plains of North America. They are now more numerous in South America than in any other part of the world.

³ In India a species of dog, called the dhole, exists in a wild state, and in Australia is found the dingo, which hunts in packs; but it is believed that these animals are the descendants of domesticated races.

To the carnivora also belong most of the valuable fur-bearing animals, such as the ermine, sable, marten, and otter. They are found only in cold regions.

11. The Marine Carnivora.—Under this division are included the seal and the walrus, which have the peculiarities of the true carnivora. Seals are found in the waters of temperate and of cold regions. The fur seal is found in cold regions only. The Pribiloff Islands, southwest of Alaska, are at present the most important breeding-grounds.

The walrus in form and habits resembles the seal. It is armed with solid tusks from eighteen to twenty inches in length. It is confined to cold and polar regions.

The seal and walrus are invaluable to the inhabitants of the Arctic regions, as they not only constitute their staple food, but contribute in a variety of ways to their necessities and comfort, furnishing fuel, light, thread, clothing, and covering for their boats and tents.

The sea-otter, which is sometimes included among the marine carnivora, belongs more properly among the weasel family. It is found chiefly along the Alaskan coast of North America. It is highly prized on account of its fur.

12. The Ruminants.—This order includes the cud-chewing animals, or those that live upon vegetables.

They are distributed over the globe from the equator to the polar regions, and are essentially connected with the welfare and diffusion of the human family.

From the earliest period, some of them have been domesticated; and, with the exception of the more desolate regions of the Arctic climes and a few of the Pacific isles, there is hardly a spot on the globe where the ox, sheep, and goat are not found.

The deer is distributed over nearly the whole globe. Among the most noted of this family are the fallow-deer, the reindeer, and the elk. The reindeer is found in the north of Europe, and is confined to polar regions. To the inhabitants of these regions it furnishes flesh, milk, and the means of transportation, carrying them rapidly on sledges across the snowy wastes.

The elk, or moose-deer, has its home in the coldest parts of the north temperate zone. It was formerly numerous in Europe, but is now found chiefly on the Western Continent, in the vicinity of the great lakes and the forests of the St. Lawrence River.

The giraffe is found only in Africa. The antelope inhabits chiefly the warm zones of Africa. A few species, however, are found in Asia and America.

The ox, one of the largest of the ruminants, is diffused over nearly the entire globe. It has been so long domesticated that

its origin is unknown; but Central Asia is generally regarded as the home of the parent stock.

The American bison, incorrectly called the buffalo, formerly dwelt in the central plain of North America. It is found now only in the southwestern part of Canada.

The musk-ox inhabits the polar regions of North America, and is distinguished for a strong, musky odor, whence it derives its name.¹

The goat is found in certain portions of Europe and Africa, but abounds chiefly on the Asiatic Continent. The original stock of the common goat is unknown, but it is probably the same as that of the half-tamed breeds that inhabit Asia.²

The sheep appears to have been the first animal domesticated

by man, and its native abode is supposed to be in Western Asia. In the inaccessible mountains of Europe, Asia, Africa, and America sheep herd in a wild state. Wild sheep are most numerous in Asia.³

The Arabian camel is distributed over Southwestern Asia, the south of Tartary, and part of India. It is peculiarly fitted by its structure for traversing arid regions. It possesses a supplementary stomach as a reservoir for water, and its fatty hump, when the animal is without sustenance, is partly absorbed as food.⁴ The Bactrian camel is found in Central Asia and in the countries bordering on the Caucasian Mountains.

The llama resembles the camel, but is much smaller, possessing neither hump nor additional stomach. It belongs exclusively to South America, and is restricted to the lofty ranges of the Western Andes.⁵

13. The Quadrumana.—The quadrumana, or four-handed animals, comprise the apes, monkeys, baboons, and lemurs. They are confined almost exclusively to moist, tropical regions.

The most remarkable of all the apes is the gorilla, which lives in Western Africa. It is from six to seven feet high, and is noted for its strength and ferocity.

The monkeys of the Western Continent are distinguished by having tails. They are smaller than the tailless monkeys of the Eastern Continent. The lemurs are found in Madagascar only.

climes, which changes in a year or two to crisp brownish hair if the animal is transported to tropical latitudes.

⁴ The Arabian camel has one hump; the Bactrian camel, two. The dromedary is a trained camel distinguished for speed. The Arabian camel has been employed as a beast of burden in the deserts of Arizona.

⁵ This animal is more sure-footed than the mule, and is largely employed in transporting the products of the South American silver-mines across the rugged ranges of the Andes.



FLYING LEMUR.



GIRAFFES.

¹ Sergeant Brainard, of the Greeley Expedition, found the musk-ox as far north as latitude 82°.

² The Syrian goat is much prized for its milk; and its hair from a very early period has been employed in the manufacture of cloths. From the fine and silky hair of the Cashmere goat are fabricated the beautiful and costly Cashmere shawls.

³ This valuable animal is greatly affected by external circumstances, and especially by climate, producing a thick and silky fleece in the temperate

14. The Cetaceans.—The cetaceans surpass all other mammals in size. They are marine animals, and include various species of the whale and the dolphin.

The whalebone whale is found chiefly in the northern oceans. The sperm whale ranges over nearly the entire ocean, from the 60th parallel of north latitude to about the 70th degree of south latitude.

The dolphin ranges throughout every sea, from the equator to the poles. The porpoise, a species of dolphin, is a strong and voracious animal, living in the colder waters of the ocean.

15. Mutual Dependence of Plants and Animals.—All life is dependent upon the earth, the water, the air, and the sunbeam; and a mutual relation exists between vegetable and animal life. Plants inhale carbon dioxide and exhale oxygen, while animals inhale oxygen and exhale carbon dioxide. Thus these two great kingdoms minister to each other, and preserve the balance in the constitution of the atmosphere, rendering it a common nourisher to every form of life.

CHAPTER IV.

ETHNOLOGY.

1. Ethnology is the science which treats of the races of mankind and of their distribution over the globe.

2. Population.—The population of the earth is estimated at 1,445,000,000. This is distributed among the grand divisions of the earth as follows:

Asia (including Malaysia).....	799,000,000
Europe.....	334,000,000
Africa.....	206,000,000
North America.....	72,000,000
South America.....	30,000,000
Australia and Polynesia.....	5,000,000

3. Position in Nature.—Man belongs to the order of *bimana* in the class of mammals, and is distinguished, therefore, as holding the highest place in the animal kingdom. In physiological structure he does not differ from other species of the higher orders of animals. In physical strength he is inferior to most species.

The chief feature which distinguishes man is the remarkable development of his mental faculties. He has the power of articulate speech and of abstract thought. He uses tools and mechanical devices, and is the only animal that has a knowledge of the use of fire.

4. Physical Appearance.—The human race is distinguished by the peculiarities which mark the varieties of other species of animals. Various divisions of people differ in height, color of skin, hair, and eyes, and in the form of the skull.

¹ Apart from color, the hair of different races has other peculiarities. Thus, the hair of the negro is wiry and crisp, having the appearance of wool. A transverse section of the hair is *circular* in shape. The hair of the European is soft, silky, and usually very fine as compared with that of the Mongol or of the American Indian. A transverse section of the hair of the Aryan is always *elliptical*.

² Aryan, from a Sanskrit word meaning *tillers of the earth*; ³ Semitic, the descendants of Sem, or Shem; ⁴ Turanic, from a Sanskrit word meaning *horsemen*; ⁵ Hamitic, the descendants of Ham; ⁶ Negro, from a Latin word meaning *black*. The Aryans are sometimes called the *Japhetic* race. By many ethnologists the Aryan and Semitic races, together with the

The difference in height is a noticeable one. Thus, the Esquimaux, Fuegians, and Bushmen are of somewhat diminutive stature, while the Caribs, Kaffirs, and Zulus are remarkably tall. The average height of the Englishman is five feet seven and one-half inches, the height of the Kaffir is about six feet, while that of the Bushman is only four and one-half feet.

Difference in color is one of the most marked distinctions of mankind. The color of the skin ranges from a deep black, through shades of brown, red, yellow, and olive, to white.

The color of the skin in general corresponds with that of the eyes and hair. Races of dark skin have usually black hair and dark eyes. On the contrary, in races of light complexion, the hair is almost always brown, and the eyes are light-blue or gray.¹

The color of the skin is not of permanent character. It is regarded as due to climate, food, and habits of life. In many instances tribes and families intimately related differ widely in color, while those of different races exhibit little or no difference in this respect.

The form of the skull is one of the most important distinctions of physical structure. Thus, an oval skull characterizes peoples of Aryan and of Semitic descent; a pyramidal skull distinguishes the Turanic or Mongolian race; while the various Negro or Hamitic tribes are distinguished by narrow, elongated skulls.

5. Races.—The human family is comprised in four great races. These divisions are based upon *language*. Many nations and tribes, differing in physical appearance, manner of living, and social customs, are included in each race.

These races are called the Aryan,² or Indo-European, the Semitic,³ the Turanic,⁴ and the Hamitic,⁵ or Negro.⁶ Each race comprises one or more subdivisions.

6. Aryan Race.—This race is often called the Indo-European race. It is thought to have sprung from India, but the finest types are now found in Europe.

The physical characteristics of this race are an oval skull, light or dusky skin, and silky hair, varying from light-brown to black. Thin lips, high foreheads, and finely-modelled features likewise distinguish it. The Aryans include the most beautiful and intellectual portion of the human family.

The most powerful nations of antiquity, such as the Hindoos, Egyptians, Assyrians, Greeks, and Romans, sprang from this race. In modern times its supremacy is still maintained, for the descendants of the Aryan stock are now the ruling nations of the earth.

The geographical distribution of the Aryan race is limited only by the land-area of the earth, but its most perfect development is seen in the north temperate zone. The various Asiatic peoples which compose it include those of Hindoostan, Persia, Afghanistan, and parts of Tartary. Except the Turks, Magyars, Laps, and Finns, all the nations of Europe belong to this race. It includes also the Copts of Egypt, the Nubians, the Abyssinians, and the Berbers of the North African States.⁷

Circassians and Georgians, are classed as the Caucasian race. Those tribes of the Turanic race dwelling in Northern Asia, Turkey, Hungary, Finland, and Lapland, are classed as Mongolians. The Malays and American Indians are frequently classed as separate races, but more commonly as subdivisions of the Mongolian race.

⁷ It must be borne in mind that not all of these people are of pure Aryan stock. On the contrary, there is a considerable admixture of negro blood in all the African peoples originally of Aryan descent. In Egypt, Nubia, and Abyssinia, Negro blood predominates; only the Copts retain the characteristics of the Aryan race. The fellahin of the Upper Nile are hardly to be distinguished from Negroes.

Within the last three and a half centuries, descendants of the Aryan race, migrating from Europe, have colonized America, Oceanica, and parts of Africa, and being the more powerful people, have gradually supplanted the native races of these countries.¹

The following table shows the distribution of the Aryan race in Europe, arranged with reference to their language:

Aryan Stock	Tentonic.....	Germans.
		English.
		Danes.
		Swedes.
		Norwegians.
	Slavonic.....	Dutch.
		Russians.
		Poles.
	Romance.....	French.
		Italians.
		Spanish.
		Portuguese.
	Celtic.....	Irish, or
		Highland Scotch, or Gaels.
	Greek.....	Welsh, or Cymri.
		Ancient and modern.
		Persian.....Various dialects.
	Hindoostanee.....	Various dialects.

7. Semitic Race.—The Semitic race is supposed to have originated somewhere near the same locality that gave birth to the people of the Aryan race.

In physical characteristics the Semitic peoples do not differ greatly from the Aryans. Dark skins, black hair, and black eyes are prevailing types.

The territory of this race is small compared with that of the Aryans, and is confined chiefly to Southeastern Asia and Northern Africa. Unlike the Aryans, the Semitic race has not migrated far from the place of its origin.

The living descendants of the Semitic race comprise the Arabs, Syrians, and Hebrews, or Jews.² Of these the Hebrew people are the most eminent. Their descendants have spread over Europe and America, and rank among the most enlightened people in the world.

In religious belief the Semitic people are monotheists, or believers in one God. The Arabs form a religious sect known as Mohammedans.³

8. Turanic Race.—The Turanians are called also Mongolians, a name formerly used to designate certain Tartar tribes, which were considered the finest types of the race.

The physical characteristics are a pyramidal skull; yellow, red, or brown skin; coarse black hair, black eyes, and scanty beard.



ARYAN—EUROPEAN.

Moderately thin lips, high cheek-bones, and a receding forehead are also prominent characteristics of the various divisions of this race. Many of the tribes are distinguished for fine physical appearance and personal beauty. This is especially true of the Georgians, Circassians, and others who dwell in the Caucasus highlands.

This race comprises more than one-half of the total population of the world. The geographical distribution of the Turanic race is nearly as wide as that of the Aryans, but probably is not quite so diffuse.

The Mongolian Division embraces the Chinese, Burmese, Siamese, and most of the people of the Farther Indian peninsula. It includes also most of the tribes in the valley of the Amoor River and the plains of Tartary.



TURANIAN—MONGOL.

In Europe it comprises the Magyars of Hungary and the Finns and Laps of Russia. The Esquimaux⁴ and some of the Indian tribes of the western part of North America are thought to belong to this division. The Japanese⁵ also show many characteristics of Mongolian descent.

The Malay Division of the Turanic race derives its name from the Peninsula of Malacca, where its most distinguishing types are found. The typical Malay has a brown or swarthy skin, and is more robust in stature than the Mongol.

The territory of the Malay is confined to the Malay Peninsula, a few of the islands adjoining Asia, and all of Oceanica except Australasia and Melanesia. Most of the Malay tribes are in a savage state.

The Hovas and several other tribes of Madagascar belong to this division of the Turanic race. The former are intelligent and advanced in civilization.

The Japanese are by far the most superior people of the Malay division. Their civilization and literature place them among the highest types of the human race. No other nation on the face of the earth has made such rapid progress in the arts and sciences as have the Japanese during the past twenty years.



TURANIAN—MALAY.

The American Division receives its name from the country in which the aboriginal Americans were first found. They are incorrectly called Indians.⁶

In physical appearance the Americans of the Pacific coast resemble the Mongolian type, and the resemblance is strongest in the northwest, where the two continents approach each other. This resemblance disappears among the tribes who live east of the Rocky Mountains.

¹ Just, in fact, as the American Indians supplanted the people whom we now know as the "Mound-builders"—a people who occupied the land, and whose ruined habitations are now scattered over the continent from Hudson Bay to Patagonia. In a few instances the Aryan colonists have intermarried with the natives, producing a hardy and prolific race. A notable instance of this is seen in the *Mestizos*, or Spanish-Americans, of Mexico and South America.

² The Phoenicians, Carthaginians, Chaldeans, Babylonians, and Ninevites—all of whom have disappeared, either by conquest or by absorption into other races—belonged to the Semitic race.

³ They worship God, but they believe Mohammed to have been an inspired prophet.

⁴ Dr. Octave Pavy, the Arctic explorer and naturalist, one of the best authorities on this subject, doubts the Mongolian descent of the Esquimaux, though admitting their classification with the Turanic race.

⁵ Professor Edward Morse, after a thorough investigation, concludes that the Japanese are more properly classed with the Malay division. The Ainoes of Japan have but few characteristics in common with the Japanese.

⁶ They received this name at the time of the discovery of the New World, on the supposition that the land was the coast of India.

On the Pacific Coast the various tribes of this division are characterized by low foreheads and dusky skins. East of the Rocky Mountains, however, the prevailing features are copper-colored skins, high cheek-bones, and moderately high foreheads.

The "Indians" of the Great Central Plain are by far the finest types of this division. They are distinguished by a cold, phlegmatic temperament, and exhibit a wonderful endurance and indifference to pain. They are noted also for their cruelty and revengeful disposition.



TURANIAN-AMERICAN.

The territory of the American division embraces the Western Continent. A few tribes are still to be found on the adjacent islands. In North America this race is rapidly disappearing before the more powerful Aryans. In Mexico, Central America, and South America it has become a mixed race by intermarriage with Spanish and Portuguese, and also with Negroes.¹

The various jargons spoken by the tribes of this division show little similarity to one another.²

9. Negro Race.—The Negro, or Hamitic, race is by many ethnologists supposed to be descended from Ham, one of the three sons of Noah.

The typical features which distinguish this race are: elongated and narrow skull, black skin, black and woolly hair, and profuse beard. Thick and protruding lips, high and receding foreheads, and a thick, flat nose are also characteristics of the Negro race.

There is, however, a notable difference among the various tribes. Some, like the Zulus and Kaffirs, are remarkable for their perfect physical development; others, like the Hottentots and Bushmen, are among the lowest types of humanity.



HAMITIC—AFRICAN.

The territory of the Negro race embraces chiefly the central and southern parts of Africa. It comprises also the basins of the Congo, Niger, and Upper Nile Rivers.

During the existence of the slave-trade, large numbers of this race were brought to America and the West Indies. Their descendants now constitute a large majority in the West Indies, and probably a little more than one-tenth of the entire population of the Western Continent.

The Negroid, or Australoid division of this race comprises a few tribes which have some features in common with the Malay type. They are more properly classed with the Negro race.

The Negroids vary in color from chocolate-brown to black, and are distinguished by large and misshapen heads and shrunken limbs. They are wholly without civilization.

The territory of the Negroids comprises Australia, Tasmania, and

the division of Oceania commonly known as Melanesia. The representative types of this division are most numerous in Papua, or New Guinea. The Negroids are therefore sometimes called Papuans.

10. Migrations of Man.—The diversities in the various peoples of the human race are wide, and for many years the causes therefor were matters of speculation only. In late years, however, a comparative study of the different languages has done much to explain them.

From the earliest times people have associated in families and clans for mutual protection and support. When, finally, a people grew so numerous that the region in which they lived could not support them, the stronger and more venturesome separated from the others and sought new fields, where they could better subsist.

But such changes are always fatal to the weaker individuals, leaving as survivors only those who can accustom themselves to new pursuits and habits. New surroundings and different modes of life have invariably compelled them to coin new words, and the difference in food and climate has changed them in personal appearance.

Thus, for many centuries people have pushed farther and farther away from the place in which mankind is supposed to have at first appeared. The descendants of the Aryan race have migrated westward through Europe, America, and Asia, until the advance-guard has reached nearly to the place from which, centuries ago, the first clan migrated.

The condition of a people with respect to their development depends much on their habits of life, and this in turn is largely governed by climate.

A moist, tropical climate furnishes an abundance of everything that supplies the animal wants of man. It also produces bodily lassitude. It follows, therefore, that a people living in such a territory, although they may become numerous, will not be apt to become a powerful nation.

In the polar regions the climate is so severe that existence is a hard struggle for the bare necessities of life. Here the body is so tormented by privation that the mind has but little opportunity for development.

In the long run, the struggle for existence has been a most powerful agent in shaping the destinies of the human race. To satisfy the pangs of hunger, man has penetrated and occupied nearly every habitable part of the earth.

As people have increased in number, the difficulties of procuring subsistence have also increased, and man has therefore called in the forces of nature to aid him in acquiring and distributing the necessities of life.

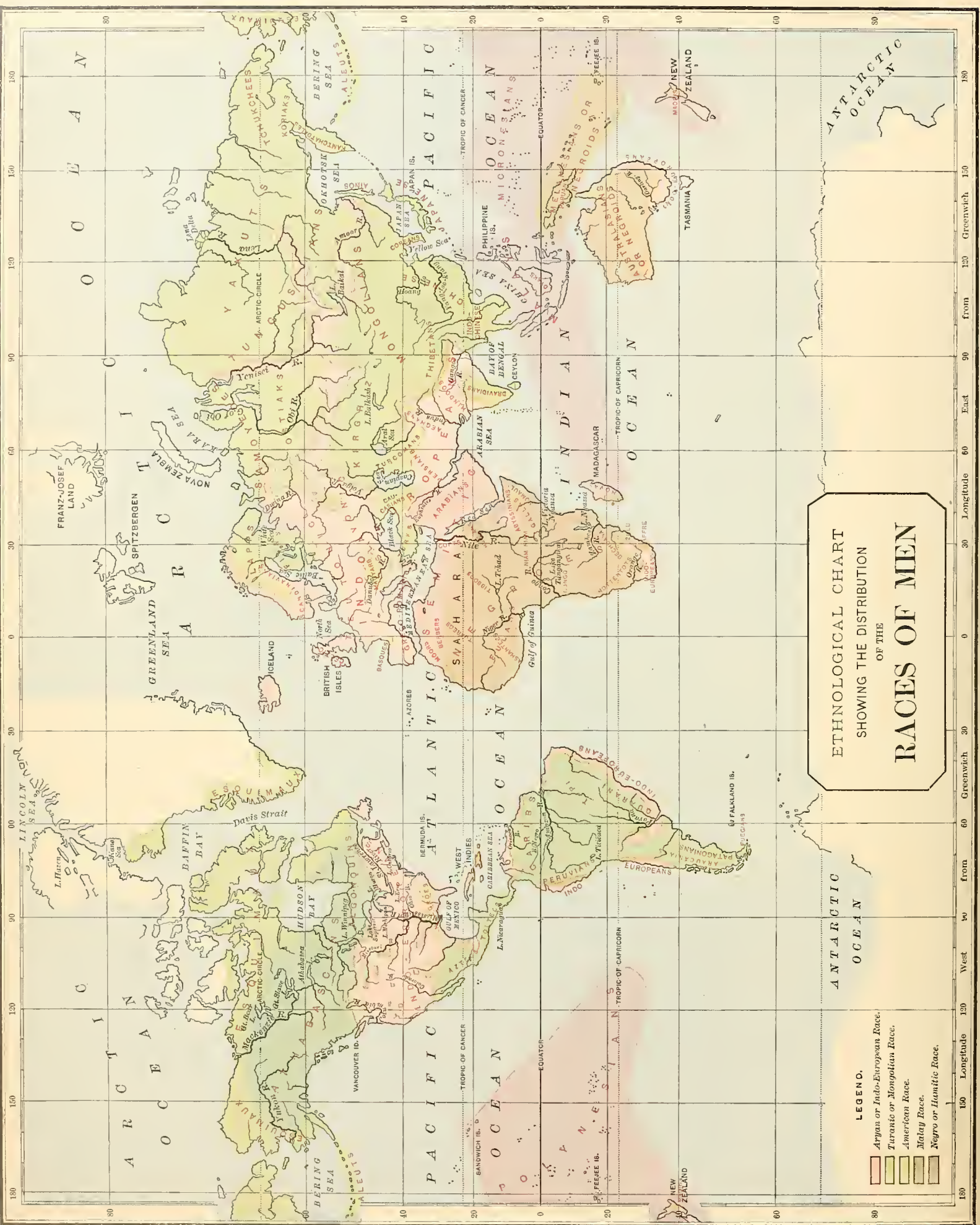
It is mainly this struggle that has elevated mankind from barbarism to civilization, for the endeavor to satisfy bodily wants has created all the great industries of the world.

In the temperate zones the conditions of climate have been such as to call into vigorous action all the faculties of man, and here, in obedience to the law of development, man has attained his most perfect structure.

worthy fact that these people, whose limits once extended as far north as the great lakes, had already begun to disappear from their northern haunts before the conquests of Mexico and South America. The Aztecs and Toltecs of Mexico and the Incas of Peru had attained a high state of civilization at the time of the Spanish conquest. It is highly probable that the Mound-builders were a part of the same race of people, and that they were driven from their homes by the more warlike Indians.

¹ The mixed Indian and Negro blood has produced the Zambos. They possess all the vicious traits of both races, but none of the better qualities of either.

² The Zuñis and Moquis, a few hundred of whom still inhabit parts of Arizona and New Mexico, seem to have little or no race relationship to the Americans. On the contrary, they appear to have much in common with the Aztecs and Toltecs, whom Cortez found in Mexico. It is a note-



ETHNOLOGICAL CHART
SHOWING THE DISTRIBUTION
OF THE
RACES OF MEN

LEGEND.

- Arjan or Indo-European Race.
- Turanic or Mongolian Race.
- American Race.
- Malay Race.
- Negro or Hamitic Race.

REVIEW AND MAP QUESTIONS ON LIFE AND ITS DISTRIBUTION.

What is said of the life of the globe and its distribution?
How is this department of Physical Geography classified?

GEOGRAPHICAL BOTANY.

Describe the vegetation of the tropical, temperate, and polar climes.
What is the result of the diversified conditions of vegetable life?
What is understood by the term flora?
What are the two great divisions of plants?
How are the Phanerogams classified?
What is an exogenous plant?
What is said of this class?
Give the several illustrations.
What is an endogenous plant?
What is said respecting this class?
Describe some of the most remarkable endogens.
Describe the zones of vegetation in regard to latitude.
Describe the zones of vegetation as respects altitude.
What is stated in respect to the diffusion of plants?
Describe the principal food-yielding plants which are found in the tropical and temperate climes, and point out on the map the regions where they grow.
What is said of the fruits of the temperate climes?
Where does the vine flourish?
Describe the plants yielding sugar, and show where they are found.
Describe the plants producing beverages.
Give an account of spice-plants.
What is said respecting medicinal plants?
Point out on the map the regions where they grow.
Give an account of the chief plants that furnish clothing. Tell from the map the countries where they flourish.
Describe the plants that furnish dyes, oils, resins, and gums.

GEOGRAPHICAL ZOOLOGY.

What is Geographical Zoology?
What is observed as to the extent of animal life?
What is said regarding its distribution?
What is stated respecting the animal life of the tropic, temperate, and polar climes?
What is said of marine life at varying depths?
What is stated in regard to the extent and diffusion of animals?
What is said of the agency of man in this particular?
How is the animal kingdom classified?

What are the characteristics of Mollusks and Radiates?
Mention the number of species included in these branches.
Give an account of Articulates.
Describe Vertebrates.
Into what classes are they divided?
State what is said of Fishes, Batrachians, and Reptiles.
How many species are included in Batrachians and Reptiles?
What is said respecting the distribution of birds?
Mention the different orders.
Give an account of each order.
How are Mammals defined?
Describe the Marsupials.
Give an account of the Edentata.
What is said of the Rodents?
Describe some of the animals belonging to these orders.
How are they distributed?
Give an account of the Pachyderms.
What is said of the Carnivora?
Give an account of the Marine Carnivora.
What is said of the Ruminants?
Give an account of the most important families.
Describe the Quadrumana.
What is said in regard to the Cetaceans?
What is said respecting the mutual dependence of plants and animals?

ETHNOLOGY.

What is Ethnology? In what order is man included?
Give an account of man and his characteristics.
What is said respecting the number and diversities of the human race?
What are the chief diversities?
What is observed respecting physical appearance and structure?
What are some of the prominent physical distinctions?
What is said respecting language?
How many races are there?
Mention them.
Describe the Aryan race.
Throughout what countries is it diffused?
Describe the Turanic race, and point out in like manner its distribution.
Give an account of the Malay division.
Describe the peculiarities of the American division. Point out its geographical limits.
Give an account of the Negro race and its distribution.
What is said concerning the migrations of the human race?

PHYSICAL FEATURES OF THE UNITED STATES.

CHAPTER I.

EXTENT, COAST-LINE AND INLETS, ISLANDS, GEOGRAPHICAL POSITION.

1. **Extent.**—The territory of the United States, including Alaska, comprises an immense region, lying between the 24th and 72d parallels of north latitude, and stretching westward between the 66th and 172d meridians. Its area is 3,622,177 square miles.

2. **Coast-Line and Inlets.**—A striking characteristic of this country is the immense extent of its shore-line; the length of the eastern coast-line being about 7000 miles, that of the southern 3400 miles, and that of the Pacific 3700 miles in extent—a total length of 14,100 miles.

Excepting the Gulf of Mexico, no large seas pierce the mainland of the United States; but the coast-line sweeps along in curves and broken lines of varied trend, forming numerous bays, gulfs, and sounds, with their corresponding peninsulas and coast projections.

The chief inlets along the eastern coast are Passamaquoddy, Penobscot, and Massachusetts Bays, Long Island Sound, New York Bay, Delaware and Chesapeake Bays, and Albemarle and Pamlico Sounds. On the Gulf shore are Barnes Sound, and Tampa, Appalachee, Pensacola, Mobile, Atchafalaya, Galveston, Matagorda, Aransas, and Corpus Christi Bays. Lakes Pontchartrain and Borgne are also arms of the sea.

On the Pacific coast are San Diego, San Pedro, San Francisco,¹ and Humboldt Bays, Puget Sound, Prince William Sound, Cook's Inlet, Bristol Bay, Norton Sound, and Kotzebue Sound.

3. **Islands.**—Along the extended coasts of this country numerous islands are found, which for the most part are of but little importance, in respect to either size or position. On the eastern coast, the principal islands are Mount Desert, a mass of primitive rock off the coast of Maine; Martha's Vineyard and Nantucket, south of Massachusetts, and Long Island.

Off the southern shore of Florida is a chain of coral formations called the Florida Reefs, and to the west of it lie the Marquesas Isles and the Dry Tortugas. Near the mouth of the Mississippi are the Chandeleur Islands. A long chain of wave-formed reefs lines the eastern and southern coast from New York Bay to the Mexican border. These are very low, being but a few feet above the sea-level.

Along the Pacific coast are the Santa Catalina and Santa Barbara Islands, lying off the shores of California.² In Alaska are the Prince of Wales Archipelago, the island of Kadiak, the Aleutian Isles, and the isle of Nunivak. The Aleutian Isles, about fifty in number, extend nearly to Asia. They are all of volcanic origin.

4. **Geographical Position.**—The United States, excluding Alaska, occupies the central portion of North America, and possesses a geographical position highly favorable to the growth and rapid development of a powerful people.

¹ San Francisco Bay is entered through a narrow strait, called the Golden Gate. The northern arm is called San Pablo Bay.

Situated between the extremes of heat and cold, its flora is abundant and varied, while the climate is such as conduces to physical and intellectual vigor. Its eastern coast is indented with numerous bays and roadsteads, which present every facility for commercial intercourse with foreign nations; while the western shores, bounded by the Pacific, open their harbors and inlets to the traffic of Asia and the ocean islands.

CHAPTER II.

PHYSICAL DIVISIONS, MOUNTAINS, AND MOUNTAIN SLOPES.

1. **Physical Divisions.**—The principal physical divisions of the United States are:

i. The Atlantic Slope, a long belt of land stretching from the St. Croix River to the Gulf of Mexico, and extending westward to the Alleghany Mountains. It nowhere exceeds two hundred miles in width, and in many places it is far less.

ii. The Appalachian Highlands, which extend from the northern part of Maine to the Gulf of Mexico.

iii. The Mississippi Basin, which includes the entire region lying between the Appalachian and the Rocky Mountain System.

iv. The Rocky Mountain System, which encloses the Basin Region, with its several ranges and included table-lands.

v. The Pacific Slope, a narrow belt of land, extending from the western flanks of the Rocky Mountain System to the Pacific Ocean, and stretching from north to south from Mount St. Elias to the peninsula of California.

MOUNTAINS.

The United States is traversed by two mountain systems, viz.: the Appalachian System on the east, and the Rocky Mountain System on the west.



MOUNT WASHINGTON.

2. **Appalachian System.**—This system consists of several parallel ridges, extending southwesterly from the Gulf of St. Lawrence to the northern regions of Georgia and Alabama. Its

² These islands are apparently a partly submerged mountain-range lying parallel to the coast of California.

breadth varies from 150 to 200 miles; its mean elevation is 2500 feet. Several of the higher ranges rise to the altitude of from 3500 to 4000 feet above the sea.

This system enters the United States in the northeastern part, under the name of the Green Mountains. It is continued through Massachusetts, Connecticut, and New York as the Green Mountains, the Hoosac Mountains, the Adirondacks, and the Catskill Mountains.

In proximity with this chain are several lofty and isolated mountain masses, the chief of which are the White Mountains in New Hampshire, and the Adirondacks in New York. The former are remarkable for their scenery. Their crests are among the highest of the Appalachian system, Mount Washington having an altitude of 6288 feet and Mount Adams of 5960 feet above the ocean.

The Adirondacks, which consist of chains of hills and irregular crests, rise in Mount Marcy to the height of 5344 feet. Isolated mountain groups occur in Maine, the loftiest of which is Mount Katahdin, 5200 feet high.

The Alleghany Mountains, as commonly known, comprise several parallel ranges, extending from the Mohawk River to Northern Alabama and Georgia. The principal and most continuous ranges are the Cumberland Mountains, the Alleghany Mountains, and the Blue Ridge. On the western side are several short outlying ridges, which constitute the foothills of the system.

The Alleghany Mountains are usually considered the main crest of the Appalachian System. They do not, however, constitute the divide, or watershed, between the Atlantic Slope and the basin of the Mississippi River; for, while the larger rivers of the Atlantic Slope rise west of this ridge, the source of the Great Kanawha, a tributary of the Ohio River, is east of it.

The highest peaks of the Appalachian System are found in North Carolina. There are about forty peaks in this system, each more than 6000 feet in height. The highest point, Mount Mitchell, has an altitude of 6711 feet.¹

The Ozark Mountains consist of a succession of low ranges extending from the Missouri to the Red River. Their average elevation is less than 1000 feet, and the highest peak only 1570 feet above the sea-level.

3. Rocky Mountain System.—This system is a part of that immense zone of highlands that extends from the Arctic Ocean to Cape Horn. It is a complex system of ridges, plateaus, and valleys, varying in width from less than fifty to more than one thousand miles.

In the United States this system comprises two series of highlands. The eastern highlands, or Rocky Mountains proper, consists of two and, in places, three principal chains, each with numerous spurs and irregular crests. The central knot of these mountains is situated in Colorado, where there are about one hundred and thirty peaks, each more than 13,000 feet in altitude. The cross-spurs, which connect the main ranges, enclose the famous parks for which this region is celebrated.

The Cascade and Sierra Nevada Ranges form the main crest of the Pacific rim of this system. They constitute a high mountain barrier, parallel to the coast and about 150

miles from it. For more than 1000 miles these mountains follow the trend of the coast, and, except where the Columbia, Klamath, and Sacramento Rivers have cut their channels through this ridge, there is no pass less than 5000 feet in height.

The Coast Range is a lower elevation lying against the coast, and forming a sea-wall that extends from Alaska to Cape San Lucas. Between the Coast Range and the high chain of mountains to the eastward is a succession of valleys, unsurpassed for fertility and for natural resources. The largest of these, the Sacramento and San Joaquin Valley, is more than 500 miles long and from 50 to 100 miles wide.

The highest peaks of the Rocky Mountain System are found in the Pacific ranges. Mount St. Elias, the highest peak in the United States, is 19,500 feet above the sea. Mounts Cook and Crillon are each about 16,000 feet, and Mount Whitney 14,898 feet in altitude.

The high plateau commonly known as the Basin Region is traversed by a multitude of parallel ranges, which extend nearly north and south. The highest of these is the crest comprised by the Uintah, Wasatch, and San Pete Mountains.

PLATEAUS.

4. The principal table-lands of the United States are "The Plains" and the Basin Region.

5. **The Plains.**—The plains consist of part of that immense belt of lofty lands which extends parallel to the chain of the Rocky Mountains, from Texas to the Great Bear Lake. This



THE PLAINS—BEGINNING OF SPRING.

great table-land, from the Rio Grande to the Upper Missouri, ascends in well-defined terraces and slopes from the Mississippi Valley to the foot of the Rocky Mountains.

This plateau consists of vast tracts of sandy soil, in some places destitute of trees and shrubs; in others, covered with a scanty growth of herbage. There is, however, an abundance of grass throughout the entire region. The largest of these tracts is best known as the Llano Estacado, or staked plain.

¹ Mount Mitchell was formerly called Clingman's Peak. Since Professor Mitchell's death and burial on the summit of this mountain, the name

Clingman's Peak, has been given to a high summit which was formerly called Mount Mitchell.

6. The Basin Region.—The Basin Region, or western plateau, comprises the area enclosed by the Rocky Mountains and the Sierra Nevada and Cascade ranges. The high ranges of the Uintah, Wasatch, and San Pete Mountains separate it into two distinct physical regions—the Great Interior Basin and the Plains of the Columbia on the west, and the Colorado Plateau on the east.

The Colorado Plateau, although traversed by numerous rivers, is situated in an almost rainless region. The prevailing rocks are of soft sandstone, and the slope of the surface is so great that the streams flow with a swift current. As a result of these two conditions, the rivers have worn their channels in places more than a mile deep. The cañons of Green, Grand, Colorado, and Gunnison Rivers are notable instances of such river gorges.

The Great Interior Basin, together with the Plains of the Columbia, constitutes a rugged volcanic table-land. The northern part, which receives considerable rain, is interspersed with fertile valleys and dotted with lakes. This part of the plateau is drained by the Columbia and Klamath Rivers.

The southern part is a true inland or steppe region. Its rivers discharge their waters into “sinks” or salt lakes. The rainfall does not exceed one or two inches a year, and when rains occur they come in the form of “cloud-bursts.”

In former times the greater part of this region was covered with water, forming an inland sea larger than the great lakes. The old shore lines of this body of water are still visible at distances of from 500 to 1000 feet above the present level of the plain. Great Salt Lake at that time discharged its surplus waters into a tributary of the Columbia River. As the Columbia River cut its channel deeper into the rocks, it finally drained the entire area, leaving the southern part an inland, or steppe region.

PLAINS.

7. The principal plains of the United States are the Great Central Plain, the Atlantic Plain, and the narrow plains which border the Pacific Ocean.

8. The Great Central Plain.—The Great Central Plain lies between the Appalachian and Rocky Mountain systems, stretching from north to south from the British Possessions to the Rio Grande. Within its limits are included the basin of the Mississippi River, the lower part of the Texan slope, the basin of the Red River of the North, and a part of the St. Lawrence basin. This immense tract is separated into two great divisions by the Mississippi River and its tributaries, which drains the greater part of it.

The Eastern Division, nearly a thousand miles in length, extends from the Mississippi to the base of the Alleghany Mountains, a distance of about 300 miles. Formerly it was covered with forests, interspersed with grassy prairies; but the woods have now to a great extent disappeared, and throughout this region the fertile land teems with abundant crops of the products adapted to its varying climate. Its fertility and productiveness are so great that it is capable of supporting a denser population than any other area of equal size in the world.

West of the Mississippi the character of the surface changes, spreading out into slightly rolling or perfectly level prairies, which are covered with grass, but destitute of tree or shrub, save along the banks of streams.

The Great Central Plain maintains its fertile character within the eastern plateau to the meridian of 100° , that being the approximate division between the productive plains and the arid and sandy table-land. Abounding in the elements of material wealth, and possessing a salubrious climate, this immense plain is one of the most important centres of influence in the Western Hemisphere.

The Atlantic Plain is a narrow belt of land extending from Massachusetts to the Gulf of Mexico: it never rises more than one hundred feet above the sea-level, and is intersected by numerous tidal creeks and inlets. The northern portion is for the greater part sandy, while the southern is swampy. In North Carolina a sandy region, known as the “pine barrens,” extends more than fifty miles back from the coast.

9. Volcanic Features.—The northwestern portion of the United States is decidedly volcanic in its character: it contains about forty volcanoes, many of which are in activity. Mounts Hood, St. Helens, Rainier, Shasta, and Whitney are extinct craters; and in the Aleutian Isles thirty-five volcanoes, nearly every one of which is active, form a main link in the vast chain of fire that girdles the Pacific Ocean.

The Yellowstone National Park, 65 miles long by 55 miles wide, lies mainly in the northwestern corner of Wyoming Territory. Its elevation varies from 7000 to 10,000 feet above the level of the sea.

There are about 10,000 hot springs within its limits, among which are 70 geysers, situated chiefly along Firehole River. Several of the latter eject columns of water to the height of 200 feet or more, while jets of steam are shot more than 1000 feet higher. The basin of Firehole River is filled with deposits of silicious matter, and many of the springs are so highly charged



FALLS OF THE YELLOWSTONE.

with silica that twigs and branches of trees immersed in their waters are quickly covered with an incrustation. The majority of the rocks are of volcanic formation. This region comprises the most extensive group of hot springs in the world.

The Grand Cañon and the Falls of the Yellowstone River are among the leading features of the Park. The Cañon varies in

width from less than half a mile to a mile, and its depth varies from 1000 to 2000 feet; its length is more than 20 miles. The Upper Fall is 112 feet in height; the Lower Fall, 300 feet.

CHAPTER III.

LAKES AND RIVERS.

LAKES.

1. Eastern System.—Lakes Superior, Michigan, Huron, Erie, and Ontario, comprising together an area of 92,000 square miles, contain most of the lake-waters of the United States. They form an immense chain of inland seas upon the northern frontier. The boundary-line between the Dominion of Canada and the United States passes through each of these lakes, except Lake Michigan, which is wholly within the United States. Besides this system, a multitude of small and less important lakes are scattered throughout the northern part of the Mississippi Valley.

Lake Superior is the largest in the chain. It has an area of 31,500 square miles, and a circumference which has been estimated at 1700 miles. Its waters, which are very pure, transparent, and deep, flow into Lake Huron on the south, through the river St. Marie. Its greatest depth is 1008 feet.

Lake Huron has an area of 23,100 square miles, and a depth of 702 feet. It is very irregular in form, and contains many bays and islands. Through the Strait of Mackinac it receives the waters of Lake Michigan, and on the south it flows into Lake Erie through the lake and river of St. Clair.

Lake Michigan has about the same area as Lake Huron. At its northern extremity is a large bay, called Green Bay. The greatest depth of Lake Michigan is 870 feet.



LAKE CHAMPLAIN.

Lake Erie is 7800 square miles in extent, and 120 feet deep. Its waters descend by the Niagara River into Lake Ontario, forming in their passage the renowned Falls of Niagara. It is also connected with Ontario by the Welland Ship Canal.

Lake Ontario, the smallest of all the lakes in this chain, contains 6900 square miles, and has a depth of 734 feet. From its northern extremity issues the noble river St. Lawrence, whose broad waters just below the lake are diversified by the enchanting scenery of the Thousand Isles.



MINNESOTA LAKE SCENERY.

The chain of the great lakes, on account of their immense extent, depth of water, and extensive coast-line, affords great facilities for internal navigation, and a vast commerce has arisen upon their waters. They possess, however, but few good harbors, and their shores in many parts are rocky and dangerous. They are subject, moreover, to fierce storms. A slight tide has been observed in Lake Michigan.

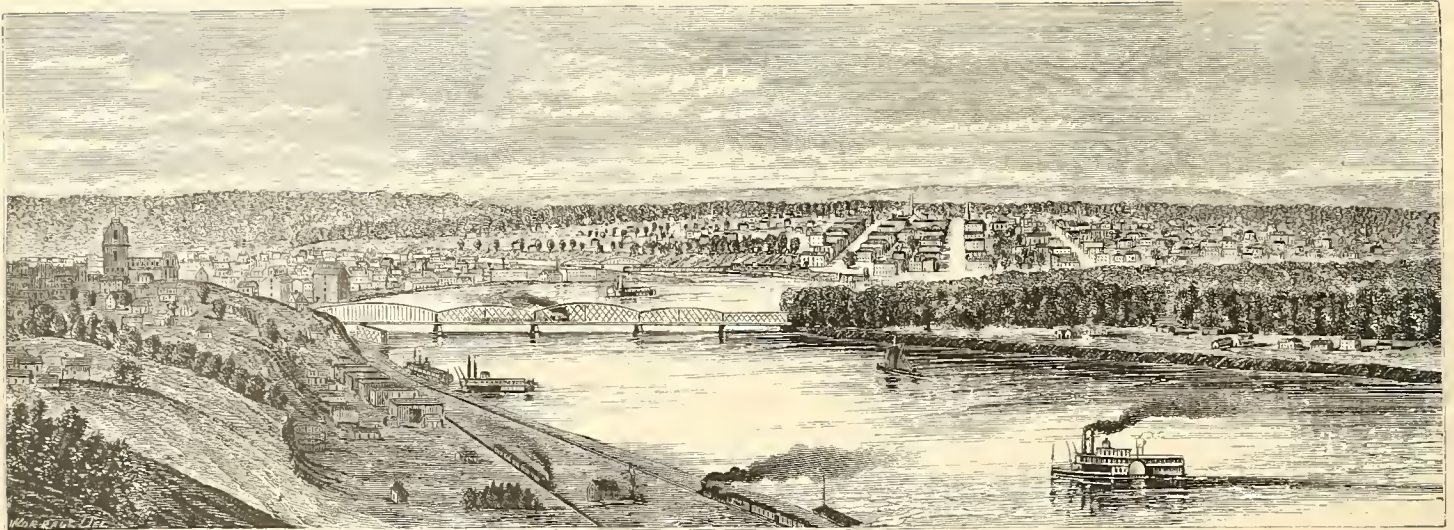
2. Other Lakes.—Lake Champlain is a beautiful expanse of water, lying between the States of New York and Vermont. It is about 120 miles long, and is diversified by more than 60 islands. It discharges its waters northward by the Sorel, or Richelieu, River into the St. Lawrence.

Lake George is a beautiful body of water, lying near Lake Champlain, into which it flows at Ticonderoga. Its waters, which are remarkable for their transparency, are studded with numerous and beautiful islands. In the interior of the State of New York are many small lakes, of which the largest are Cayuga, Seneca, and Oneida.

Numerous minor lakes are found in Northern New England, the chief among which are Mooshead and Chesuncook Lake in Maine. In New Hampshire lakes Umbagog, Connecticut, and Winnipiseogee are noted for the charms of their scenery. In Florida and along the gulf shores there are many small lakes.

By far the greatest number of lakes are found in the belt of land which constitutes the Height of Land. In Eastern Montana, Dakota, Minnesota, and Wisconsin there are about 50,000 small lakes and ponds.

3. Western System.—Most of the lakes of the Great Interior Basin are salt lakes. The largest of these is Great Salt Lake,



GREAT BEND OF THE MISSOURI RIVER.

300 miles in circumference, and having a variable area of about 2000 square miles. Its waters are almost saturated with salt, and it contains many islands, some of which reach an altitude of nearly 1000 feet above the level of the lake. About fifty miles distant is situated Lake Utah, a beautiful sheet of pure fresh water, thirty miles long and about ten miles broad, which flows into the Great Salt Lake through the Jordan River.

Great Salt Lake is subject to changes in depth, and consequently in area. From 1850 to 1868 the depth of the lake increased twelve feet. Since that time it has steadily decreased. This decrease is probably due to the diversion of the streams of water, which, formerly flowing into the lake, have latterly been used for purposes of irrigation. The waters of Great Salt Lake contain an average of 23 per cent. of saline matter.

Of the remaining lakes belonging to this system, Klamath, Goose, Harney, and Tahoe Lakes are fresh. The "sink" of Humboldt and Carson Rivers is also fresh, although it has no outlet to the sea. The waters of Mono and Owens Lakes are extremely alkaline. The bed of the former is probably the crater of an extinct volcano.

RIVERS.

4. The Rivers of the United States are comprised under several systems, each being designated by the name of that arm of the ocean into which its waters flow.

5. Hudson Bay System.—This system includes only a few streams which belong to the basin of the Red River of the North, and which empty through Lake Winnipeg into Hudson Bay.

6. Atlantic System.—The rivers of this system include those small rivers in the United States which reach the Atlantic through the basin of the St. Lawrence, and also those which flow directly into the Atlantic Ocean.

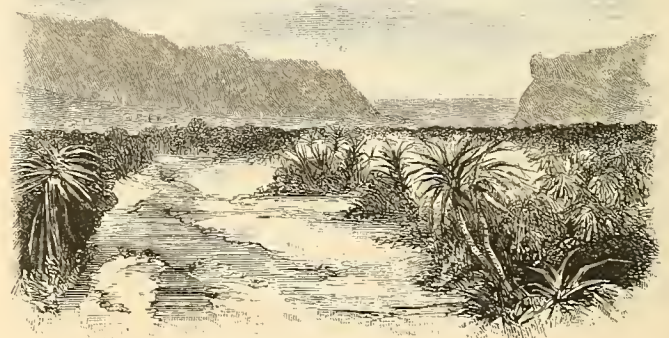
On account of the proximity of the Appalachian Mountains to the ocean, the rivers of the Atlantic system have no great length. In their upper courses they are broken by rapids and falls, which afford an immense extent of water-power.

In their lower courses, where they traverse the narrow Atlantic plain, they are navigable only for short distances from their

mouths. Several of the larger rivers of this system have their sources west of the main crest of this mountain system.

7. Gulf System.—The Gulf system embraces the basin of the Mississippi River and all other rivers flowing into the Gulf of Mexico. Most of these rivers traverse an alluvial plain formed of the sediment deposited by the rivers themselves. The Mississippi and many of the rivers of this system east of it are navigable streams and important commercial highways. In the western part they are marked by shallow waters and shifting channels.

8. Pacific System.—The principal rivers of the Pacific system are the Colorado, Sacramento and San Joaquin, Klamath, Columbia, and Yukon. The Colorado, as already described, rises in the Rocky Mountains, and flows through its stupendous cañons to the Gulf of California.



A STREAM IN THE DESERT.

The Sacramento descends southward between the Sierra Nevada and the Coast Range, and, after joining the San Joaquin, which flows northward between the same ranges, enters the Bay of San Francisco. Both these rivers are navigable more than one hundred miles from their mouths.

The Columbia has its sources in the Rocky Mountains, and

plunging from these lofty ranges in cataracts and rapids through rocky gorges in places more than 2000 feet high, enters the Pacific, after a course of 1200 miles.

The largest river of this system is the Yukon, which traverses Alaska Territory from east to west. This river is navigable nearly to its head-waters, and for a distance of 1000 miles from its mouth has a width varying from three to five miles. It probably discharges a greater quantity of water than any other North American river.

The Continental System of the Great Interior Basin includes the small streams that empty into the lakes of this region, and have no communication with the ocean. The chief river of this system is the Humboldt.

In their upper courses most of the streams of this character are mountain-torrents of considerable size. As they descend into the plain they not unfrequently disappear altogether, the water being lost by evaporation and by sinking into the soil.

At times when the evaporation is very great it sometimes happens that the river-bed or "wash," which is dry during the day, contains a considerable volume of water during the night.

CHAPTER IV.

CLIMATE AND RESOURCES.

METEOROLOGICAL PHENOMENA.

1. **Temperature.**—The territory constituting the United States is situated between the 24th and 72d parallels of north latitude. It is therefore subject to all those variations of temperature in latitude which prevail between the tropical and the Arctic regions.

The same thermal range also exists in altitude; for the southern shores of this region are bathed in the warm waters of the Gulf of Mexico, while its loftiest peaks are crowned with perpetual snow.

The greatest extremes of temperature are found in the northern part of Minnesota and Dakota. Here, at times, the heat of summer rivals that of the southern coast, while the winters are nearly as cold as those of the Arctic regions.

The Colorado and Gila Deserts are, in all probability, the regions of most intense heat. At Yuma, Arizona, the temperature frequently reaches 115°, while at stations more remote from the Colorado River a temperature of 125° is occasionally registered.¹

The regions of most uniform temperature are those which are situated on the coasts. The temperature of the Atlantic slope is more varied than that of the Gulf of Mexico, and here the changes of temperature are much greater than on the Pacific coast.

The highest mean temperature in the United States occurs at Key West, Florida, where from the observations of fourteen years a mean annual temperature of 70°.51 has been deduced. The lowest mean yearly temperature is probably at Fort Yukon,

Alaska, where the average temperature during the year is about 16°. The following table shows the average temperature of the more important places in the United States:

STATION	LOCALITY	LATITUDE.	AV. TEMP. JUNE, JULY, AND AUGUST.	AV. TEMP. DEC., JAN., AND FEBRUARY.	AVERAGE RAINFALL (INCHES).
Sitka, Alaska.....	Pacific Slope.....	57° 3'	51	35	102.3
Olympia, W.T.....	Pacific Slope.....	47° 2'	59	37	69
Pembina, Da.....	Red River Valley...	49°	64	5	21.1
Duluth, Minn.....	Lake Region.....	46° 48'	65	15	33.4
Portland, Ogn.....	Pacific Slope.....	45° 30'	65	40	53.5
St. Paul, Minn.....	Mississippi Valley...	46° 53'	71	18	29.6
Eastport, Me.....	Atlantic Slope.....	44° 55'	58	25	48.6
Milwaukee, Wis.....	Lake Region.....	43° 3'	66	28	34.6
Buffalo, N.Y.....	Lake Region.....	42° 53'	68	32	37.1
Boston, Mass.....	Atlantic Slope.....	42° 21'	68	32	50.8
Salt Lake, U.T.....	Great Basin.....	41° 10'	74	27	18.9
Chicago, Ill.....	Lake Region.....	41° 52'	73	31	35.3
New York, N.Y.....	Atlantic Slope.....	40° 42'	72	37	43.3
Sacramento, Cal.....	Pacific Slope.....	38° 35'	73	44	22.9
Denver, Col.....	Rocky Mountains...	39° 45'	71	39	15.4
Cincinnati, O.....	Mississippi Valley...	39° 4'	77	44	42.4
Philadelphia, Pa.....	Atlantic Slope.....	39° 52'	73	36	41.2
Washington, D.C.....	Atlantic Slope.....	38° 53'	76	42	42.8
San Francisco, Cal.....	Pacific Slope.....	37° 47'	58	48	23.2
Louisville, Ky.....	Mississippi Valley...	38° 18'	77	46	48.4
Lynchburg, Va.....	Atlantic Slope.....	37° 30'	77	45	41.8
Los Angeles, Cal.....	Pacific Slope.....	34° 3'	65	50	17.1
Atlanta, Ga.....	Gulf Slope.....	33° 45'	77	52	50.3
Yuma, A.T.....	Colorado Basin.....	32° 43'	88	53	2.7
Vicksburg, Miss.....	Mississippi Valley...	32° 23'	80	56	56.7
Savannah, Ga.....	Atlantic Slope.....	32° 5'	82	58	55.2
San Antonio, Tex.....	Gulf Slope.....	29° 28'	85	59	31.2
New Orleans, La.....	Gulf Slope.....	29° 58'	82	61	65.5
Key West, Fla.....	S. Extremity U.S....	24° 32'	84	73	39.7

The departures of the isotherms from the parallels of latitude vary in different parts of the country. Within the Mississippi Valley, except in the region of the great lakes, these departures are small, and places situated in the same latitude have nearly the same mean temperature.

On the east, the Appalachian Mountains produce by their elevation noticeable deviations. On the west, such is the effect of the Rocky Mountain system, combined with the winds from the Pacific Ocean, that the isothermal curves range approximately with the meridians instead of the parallels.²

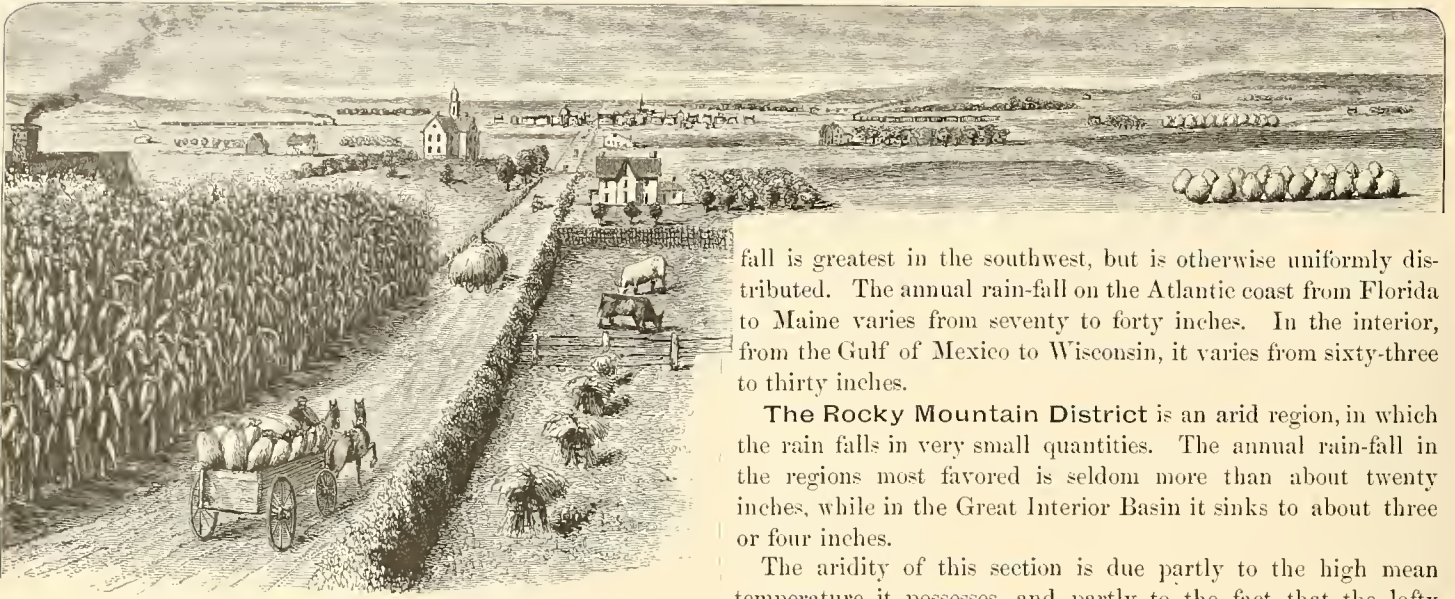
2. **Winds.**—The greater part of the United States is situated within the region of variable winds, the general direction of which, as already mentioned, is 87½° west of south. In the interior, local winds prevail to such an extent that the normal direction is the exception rather than the rule.

Throughout the whole coast of the Gulf of Mexico southerly winds prevail, which are stronger and more continuous to the west of the Mississippi than they are to the east of it. These winds possess somewhat the character of monsoons, alternating with the northern winds, which are the storm-winds of the coast. They spread their genial influences over the Great Central Plain, and

¹ At Dos Palmas a temperature of 132° has been registered.

² Thus, for instance, the isothermal of 45° passes near Dover in New Hampshire, and, sweeping westward, rises into the British Territory north of Montana; then, turning southward, it extends as far as New Mexico, where, bending again, it runs northwest to a higher latitude than before. The table presents a similar illustration: the mean winter temperature of

Sitka is one degree lower than that of Philadelphia, though the latter city is more than seventeen degrees south of the former. A more striking illustration is the comparison of the summer temperature of Los Angeles, California, with that of St. Paul, Minnesota. The latter place, although nearly seven degrees higher in latitude, has a mean summer temperature warmer by six degrees.



THE GRAIN HARVEST.

at length blend with the atmospheric current flowing to the eastward.

Northwesterly Winds are very frequent throughout the United States. They are regarded as portions of the polar currents, which are deflected from their courses by the Rocky Mountains. Turned by these barriers, they sweep across the land, and exert a beneficial influence upon its climate.

The cool and humid northeast winds which prevail along the Atlantic Slope are especially marked in New England. Land and sea breezes occur, with more or less striking alternations, throughout the whole coast of the United States, and temper the climate of the coast-belt to no small extent.

The Pacific Slope is swept by ocean winds throughout the whole year. In the summer their prevailing direction is southward, in winter northward. These winds have much the nature of monsoons, especially in Southern California.

Tornadoes limited in area, but of terrific violence, are common throughout the upper part of the Mississippi Valley. The eastern coast and its adjacent waters are swept from time to time by the cyclones which follow the Gulf Stream.

3. Rains.—In regard to the distribution and quantity of rain, the territory embraced in the United States is classed under three distinct regions:

i. The eastern division, which includes the Atlantic Slope and the Central Plain as far west as the edge of the eastern table-land of the Rocky Mountains.

ii. The Rocky Mountain zone, with its plateaus, limited on the west by the crests of the Sierra Nevada and Cascade ranges.

iii. The Pacific Slope.

In the **Eastern Division**, the rains fall in copious measure throughout the year. The winds which here prevail reveal the cause of this full and continuous supply. The moist southerly winds from the Gulf, moving onward into the higher latitudes, are in perpetual conflict with the cold and dry winds from the north and northwest. Copious rains therefore follow. The rain-

fall is greatest in the southwest, but is otherwise uniformly distributed. The annual rain-fall on the Atlantic coast from Florida to Maine varies from seventy to forty inches. In the interior, from the Gulf of Mexico to Wisconsin, it varies from sixty-three to thirty inches.

The **Rocky Mountain District** is an arid region, in which the rain falls in very small quantities. The annual rain-fall in the regions most favored is seldom more than about twenty inches, while in the Great Interior Basin it sinks to about three or four inches.

The aridity of this section is due partly to the high mean temperature it possesses, and partly to the fact that the lofty mountain-ranges on the west arrest the constant and humid current which flows easterly over the Pacific Ocean.

The **Rains of the Pacific Slope** are periodical in their character, and almost the entire precipitation occurs during the winter and spring months. The rain-fall varies from ten inches in San Diego to more than one hundred inches in Alaska.¹ It is much greater on the western slopes of the mountain-ranges than in the valleys east of the Coast Range.

The results of observations made in this region show that the rains are chiefly due to the prevalent winds, which, sweeping over the Pacific, are loaded with moisture.

4. Summary.—The Atlantic Slope and the Great Central Plain possess a climate marked by oceanic as well as continental characteristics. The greatest precipitation of moisture is found along the coast, the rain-fall decreasing with the distance from the sea. It is distinguished for the most part by great extremes of temperature, low winter temperatures alternating with high summer heats.

This region is also remarkable for its sudden changes in temperature. Variations of forty degrees in temperature in twenty-four hours are not uncommon.² Such extreme thermal changes are connected with much variation in respect to humidity, periods of great moisture being sometimes followed by severe droughts.

In the **Rocky Mountain Zone** it is more uniform, on the whole, but possesses much variety in different parts. It is continental in character, and resembles that of other high plateaus. The air in this region is dry and rarefied, and so arid is the soil in places that its finer particles are driven by the winds into drifts, which are often many feet deep.

The annual temperature, though lower than in the corresponding latitudes in the east and west, does not sink so much as might be expected from the great altitude of this district. The diurnal changes of temperature are exceedingly great, the thermometer being sometimes below the freezing-point at sunrise, and rising to 80° in the hottest part of the same day.

The **Pacific Slope** possesses a climate like that of Western

¹ The amount of rain-fall depends much on the locality. The western slopes receive much more rain than the eastern.

² At Hartford, Connecticut, during the month of February, 1861, the thermometer sank *sixty* degrees in the course of *sixteen* hours.

Europe. It is much more uniform than that of the Atlantic Coast, the summers being comparatively cool, and the winters warm and equable.

Unlike the atmosphere of the eastern shores, that of the Pacific Coast is dry and invigorating as far north as Sitka, Alaska. Beyond this point the humidity becomes excessive. From Oregon to the Peninsula of Alaska the climate is singularly genial for such high latitudes. This mildness of temperature is caused by the Kuro Siwo, which carries the warm waters of the equator across the ocean to America, and thence southward along its shores back to the equator.

Southern Alaska is as warm in winter as the coast of New Jersey, and its average yearly temperature is more uniform. In the southern part of the Pacific Slope, so extraordinary are the richness of the soil and equability of the climate, that fruits and grains attain a most remarkable development.

RESOURCES.

5. Agricultural Products.—The staple agricultural products of the United States are grain, cotton, tobacco, sugar, rice, potatoes, and hay. Of the first named, corn and wheat are the most important crops.¹

Corn flourishes from the plains of Texas to the Red River basin. It matures best in the Mississippi Valley.

Wheat has an extensive range of growth, but the chief wheat-fields are in the Mississippi Valley. The annual yield of wheat in this valley is about equal to that of the whole of Europe.

Cotton is the staple product of the Southern States. Sea-island cotton, which is celebrated for its long and silky fibre, is cultivated on the islands bordering the coast.

Tobacco, though chiefly produced in Kentucky and Virginia, is extensively cultivated in most of the Southern States.

Rice is confined almost exclusively to the lowland coasts of the South Atlantic and the Gulf of Mexico.

Sugar-Cane is one of the staple products of the Gulf States. Sorghum, a sugar-yielding plant, is cultivated in various parts of the Mississippi Valley.

6. Mineral Products.—Building-stones are abundant in all parts of the United States. New England, and especially New Hampshire, abounds in granite. Immense deposits of sand-stone of an excellent quality occur throughout the Connecticut Valley and the basin of the Mississippi River.

Marble is very widely distributed. The white marble of Vermont is of a very superior quality. Variegated and clouded marbles occur in Pennsylvania, Maryland, Tennessee, and California. Limestone abounds in all parts of the Mississippi Valley.

Precious Stones are not common within the United States. Diamonds of inferior quality have been found in North Carolina and in California. Topaz occurs at Monroe, in Connecticut; chalcidony is abundant in the Rocky Mountains; emeralds and agates are found in great profusion along the shores of Lake Superior and in the Pacific highlands.

¹ In 1880 the aggregate of the staple products was as follows:

Corn.....	1,754,591,676 bushels.	Rice.....	110,131,373 pounds.
Wheat.....	439,483,137 bushels.	Tobacco.....	472,661,157 pounds.
Oats.....	407,858,999 bushels.	Cotton.....	5,735,359 bales.
Barley.....	43,997,435 bushels.	Sugar.....	178,872 hog-heads.

² Since their discovery in 1848 these mines have yielded gold to the value of \$1,600,000,000.

Gold occurs at intervals in a belt which extends from northern New England to Georgia, the southern portion being the most productive. In North Carolina the gold-fields extend over an area of one thousand square miles.

But the most productive gold-region is the western slope of the Sierra Nevada Mountains, which has yielded more of this metal than any other region in the world.²

Silver occurs in small quantities in some of the Eastern States, and is also associated with the copper of the Lake Superior districts. This precious metal is widely distributed throughout the great Western mountain-zone, being found chiefly in New Mexico, Arizona, California, Nevada, and Oregon.

The Coal-Fields of the United States are larger than those of all the rest of the world together. They are comprised in several distinct regions.³ Anthracite coal is found in Eastern Pennsylvania. In other localities the coal is bituminous. The coal of the Pacific Coast occurs in the more recent geological rocks, and is commonly known as lignite, or brown coal.

Salt is abundant in many localities. Salt springs occur in many places, being found in Michigan, New York, Kentucky, West Virginia, and other parts of the country.

Iron is very widely diffused throughout the country. Valuable ores are found in the Northern States. Extensive beds also occur in Pennsylvania, New York, and Ohio. The immense deposits of Missouri exceed all others, both in their extent and purity, the iron forming whole mountains, as in the case of Pilot Knob and in that of the Iron Mountain.

Copper is found in the region of the great lakes, in the Appalachian Mountains, and in the Pacific highlands. The copper region of Lake Superior probably surpasses in richness all others in the world. The metal is here found in a pure state, and in immense masses.⁴

Lead occurs in Missouri, Illinois, Iowa, and Wisconsin. It is also found in the Appalachian Mountains, in Oregon, and in the Rocky Mountains. Zinc occurs in New Jersey and in the Great Interior Basin, and nickel in Pennsylvania. Arsenic, cobalt, and antimony are found in the Rocky Mountains.

The Quicksilver-Mines of California are the only ones in the United States where this metal has been found in paying quantities. In 1882 more than half the products of the quicksilver-mines of the globe came from this State.

Petroleum, or mineral oil, is found chiefly in the upper part of the valley of the Ohio River and in Southern California. A smaller area exists in Michigan. In nearly every instance petroleum is associated with salt.

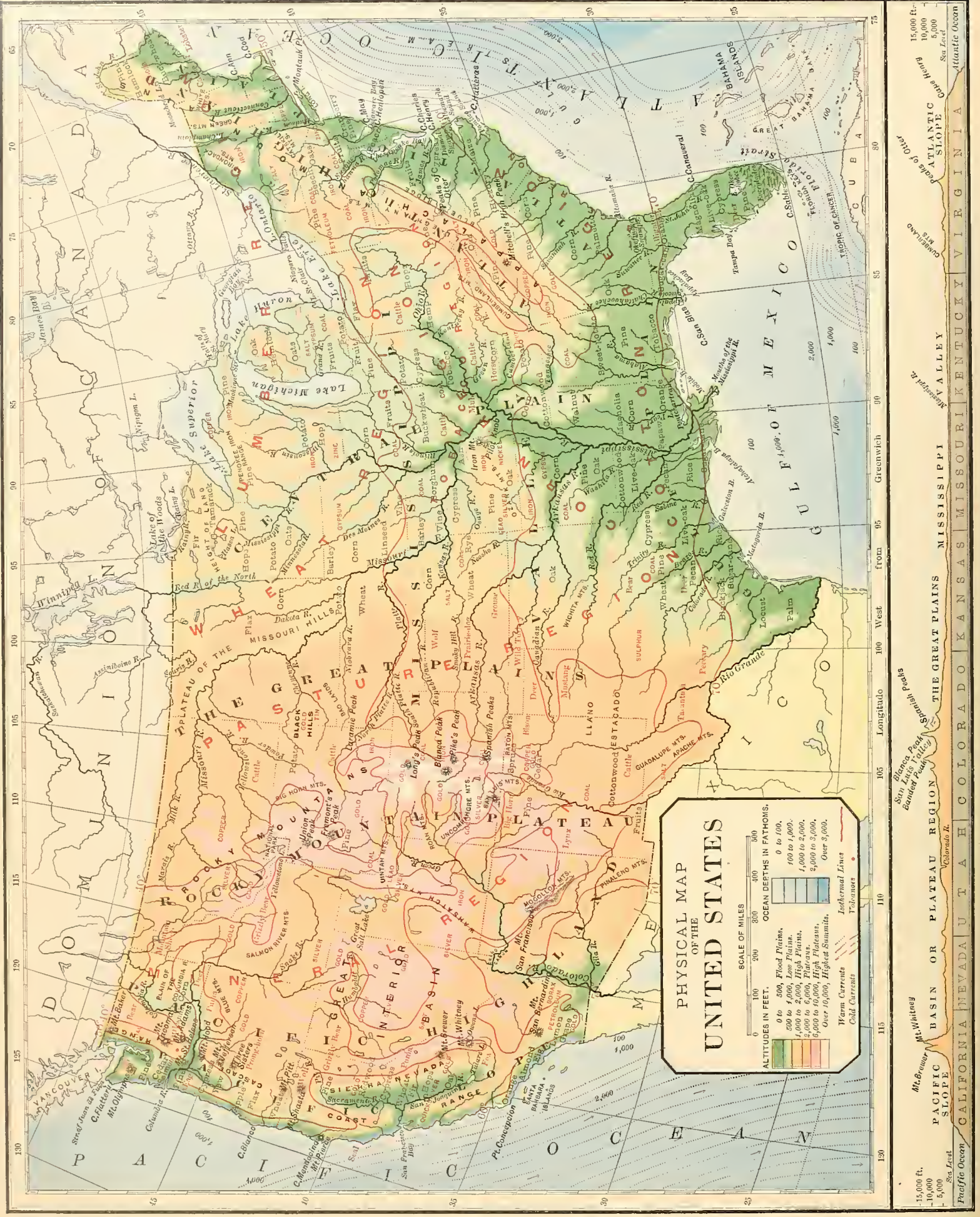
Bitumen, or mineral pitch, is abundant in Southern California, in Texas, and in West Virginia. Both of these minerals are similar in composition to bituminous coal, though they are rarely associated with it.

Natural Gas occurs in Pennsylvania, West Virginia, and Western New York. Pittsburg and a number of other cities are lighted and, to a certain extent, heated with it. It is sometimes, but not always, associated with coal.

³ The position and area of the coal-fields are as follows:

Appalachian region.....	60,000 sq. miles.	Indiana and Illinois.....	47,000 sq. miles.
Central and Michigan.....	44,000 sq. miles.	Pacific Coast.....	2,000 sq. miles.
Iowa and Missouri.....	58,000 sq. miles.	Rhode Island.....	700 sq. miles.

⁴ A single sheet of copper was discovered in the Minnesota Mine which was computed to weigh at least two hundred and fifty tons.



PHYSICAL MAP OF THE UNITED STATES

SCALE OF MILES
0 100 200 300 400 500

ALTITUDES IN FEET
0 to 500, Flood Plains, 500 to 1,000, Low Plains, 1,000 to 2,000, High Plains, 2,000 to 3,000, High Plateaus, Over 3,000, Highest Summits.

OCEAN DEPTHS IN FATHOMS
0 to 100, 100 to 1,000, 1,000 to 2,000, 2,000 to 3,000, Over 3,000.

Warm Currents
Cold Currents
Volcanic Lines

15,000 ft.
10,000
5,000
Sea Level

Pacific Ocean

PACIFIC SLOPE

Mt. Brewer
Mt. Whitney

BASIN OR PLATEAU REGION

THE GREAT PLAINS

MISSISSIPPI VALLEY

KENTUCKY

MISSOURI

KANSAS

COLORADO

UTAH

NEVADA

CALIFORNIA

Spanish Peaks
San Luis Valley
Banded Peaks

Atlantic Ocean

Atlantic Slope

Peaks of Color

15,000 ft.
10,000
5,000
Sea Level

REVIEW AND MAP QUESTIONS ON THE PHYSICAL FEATURES OF THE UNITED STATES.

EXTENT, COAST-LINE AND INLETS, ISLANDS, GEOGRAPHICAL POSITION.

- What is the extent of the territory of the United States?
- Between what degrees of latitude and longitude does it lie?
- What is said of the extent of its coast-line?
- What is the respective extent of the coast-line on the eastern, southern, and western shores?
- What are the chief inlets?
- Name the principal capes and peninsulas on the Atlantic coast, and designate them on the map.
- Name those on the Gulf of Mexico—those on the Pacific coast.
- Mention the principal islands on the Atlantic coast, and designate them on the map.
- Name those on the Gulf coast—those on the Pacific coast.
- What is said in respect to the geographical position of the United States?
- How is it situated in regard to climate?

PHYSICAL DIVISIONS, MOUNTAINS, AND MOUNTAIN-SLOPES.

- Name in order the principal natural divisions of the United States.
- What is said of the mountain systems?
- Describe the Appalachian System.
- Describe the Rocky Mountain System.
- Of what is the Rocky Mountain System a part?
- What is said concerning the Pacific chain?
- What are the chief mountain-slopes of the United States?
- Describe them.

TABLE-LANDS, PLAINS, AND VOLCANOES.

- Which are the principal table-lands of the United States?
- Of what does the eastern plateau consist?
- Describe the Staked Plain.
- The western plateau, how divided?
- Describe the Great Interior Basin.
- Mention the great plains of the United States.
- Point out on the map and describe the Great Central Plain, or Valley of the Mississippi.
- Describe the Atlantic Plain.
- What is said of the volcanoes in the United States?
- Where are they situated?
- What is remarkable respecting the volcanoes of the Aleutian Isles?

LAKES AND RIVERS.

- Point out on the map the great lakes of the United States.
- Describe Lake Superior and Lake Huron.
- Describe Lake Michigan, Lake Erie, and Lake Ontario.

- In what way do the great lakes afford facilities to commerce?
- For what are Lakes Champlain and George noted?
- Where do salt lakes occur?
- Describe the Great Salt Lake—Mono Lake.
- Name the various systems under which the rivers of the United States are comprised.
- Point out the position of each on the map.
- Give a description of the Hudson Bay System.
- What are the principal rivers of the Atlantic System?
- Of the Gulf System?
- What is said concerning the Mississippi River?
- What rivers are included in the Pacific System?
- Describe the Bering Sea and Arctic Systems.
- Trace on the map the course of the Yukon.
- Where is the Continental System?
- What is the chief river of this system?

METEOROLOGICAL PHENOMENA, CLIMATE, AND NATURAL PRODUCTIONS.

- What is said of the temperature of the United States?
- Give the highest and lowest mean temperatures.
- What is said of the departures of the isotherms from the parallels of latitude?
- What is said of winds?
- What is said of the winds of the Gulf of Mexico?
- What of northwesterly winds?
- What is said of tornadoes?
- How is the territory of the United States classed as respects the quantity and distribution of rain?
- What is said of the rain-fall on the Atlantic Slope and on the Great Central Plain?
- In the Rocky Mountain district? On the Pacific Slope? In Southern Alaska?
- In what part is the rain-fall greatest?
- Name the several climatic regions, and describe each.
- What are the staple agricultural products of the United States?
- What is said of the extent of the wheat crop?
- What of the cotton crop?
- Where is tobacco cultivated?
- Where are granite, sandstone, and marble found?
- What is said of precious stones?
- Describe the coal-fields of the United States.
- What is said respecting salt?
- Give an account of iron, copper, lead, quicksilver, silver, and gold.
- Where are the richest gold-fields in the United States?
- Where is petroleum found?



ARCTIC REGIONS.

1. **The Arctic or North Circumpolar Region** includes the Arctic Ocean and the northern shores of the continents which nearly enclose it. The lane of water between Norway and Greenland is the only wide passage connecting the Arctic with the Atlantic Ocean. The two narrow passages through Baffin Bay and Bering Strait are the routes by which vessels usually enter the Arctic Ocean.

2. **Topography.**—Much of the land surrounding the Arctic Ocean consists of low, swampy plains, called tundras. They occupy almost the entire coast of the Eastern Continent, and a part of that of the Western.

The surface of the Arctic Archipelago, however, is generally

high and rocky. Grant and Grinnell Lands are traversed by ranges of mountains. Greenland is a high plateau, having in the interior an elevation of more than five thousand feet. Most of the rock is granitic, but sedimentary rocks and coal formations are common in the Arctic Archipelago.

3. **Climate.**—The seasons of this region consist of a day, or summer, and a night, or winter. The temperature varies chiefly with the season. At Lady Franklin Bay the average summer temperature is 34° ; the winter temperature, -37° . In the south of Greenland the winter temperature is but little lower than that of the New England States. The regions of greatest cold are found in the interior. The most equable climate is found in the vicinity of Bering Sea and Spitzbergen.

4. **Life.**—The whale, seal, and walrus are the most important marine animals of this region; the Esquimaux dog and the reindeer are the most valuable land animals. The territory of the reindeer extends from Greenland to Eastern Russia. In the American continent this animal is replaced by the musk-ox. The white or polar bear, the largest land animal in these regions, is found on all highland coasts. At his farthest point north, Brainard found traces of the musk-ox, and observed water-fowl flying northward. The ptarmigan, a species of grouse, is common in these regions.

Mosses and lichens are the prevailing types of vegetation in the tundras. In the highlands, along the coast, there is a profusion of wild flowers. Brainard found species of poppy and saxifrage along the northern shore of Greenland.

5. **Inhabitants.**—The most remarkable people living in these regions are the Esquimaux. Their territory extends from the extreme eastern part of Siberia throughout Arctic America. In Northern Europe they are replaced by the Laps and the Samoyeds. The Esquimaux are of short stature and stunted in growth.

6. **Ice.**—In many parts of the Arctic regions ice accumulates faster than it melts. In the interior of Greenland the ice-cap is estimated to be more than one thousand feet in thickness. Ice of

this character is called *palæocrystic ice*. The western slope of Greenland is scored by immense glaciers, some of which are several miles in width. One of these was found by Markham to advance at the rate of nearly fifty feet a day. The icebergs broken from these glaciers float through Davis Strait, and collect at the meeting of the Arctic Current and the Gulf Stream.

Sea-water freezes at about 28° . The irregular patches which first form are called *sludge*. These finally unite into a thin sheet termed *pancake ice*, and when the latter becomes thick and firm it forms the *ice-field*. Masses of the ice-field which are blown off shore are known as *flow-ice*. If, however, the field is driven ashore, and piled in broken blocks, it forms the *ice-pack*. The *ice-foot* is a shelf of ice which forms along the shore.

7. **Open Polar Sea.**—Up to the present time it has not been shown that an open polar sea exists. Among later explorers the opinion prevails that the circumpolar sea is neither perpetually frozen nor constantly open. On the contrary, its condition is thought to resemble that of other bodies of polar waters, being filled with ice or open, according as winds and temperature may favor. At Lady Franklin Bay, Greely found that the tide came from the north, and that the water was one or two degrees warmer than at Cape Sabine, where it came from the south.

HISTORICAL.

The object of most of the early Arctic exploration was to find a short passage from Europe to India, and thus avoid the long route around the Cape of Good Hope.

The Northwest Passage.—The Northwest Passage was supposed to lie north of the American continent. As early as 1498 Cabot endeavored to find this route, but on account of the ice he could go no farther north than the entrance to Davis Strait. In 1576 Frobisher discovered the strait which bears his name, and nine years later Davis entered Baffin Bay and explored the coast of Greenland. In 1610 Hudson penetrated the ice-pack of Hudson Strait and entered Hudson Bay. Six years afterward Ballin explored Baffin Bay and Lancaster Sound. In 1819 Parry passed through Lancaster Sound and made his way as far westward as Parry or Melville Sound.

In 1845 Sir John Franklin, who already had penetrated Banks Strait from the west, attempted the Northwest Passage from the eastern side. One of his vessels was spoken in Baffin Bay in July of the same year, after which no tidings were received for more than thirty years. Through the researches of Schwatka, in 1879, it was found that Franklin and a few survivors perished near the northern part of King William's Land. Schwatka brought back many relics of the expedition.

In 1854 McClure sailed through Bering Strait nearly as far east as Barrow Strait, but being nipped in the ice-pack he was obliged to abandon his ship and continue his way overland. Pushing eastward he was met by a relief party sent in search of him, and with them he succeeded in forcing the long-sought passage.

The Northeast Passage.—Search for a Northeast Passage was made almost as early as that for the Northwest Passage. In seeking a route along the northern shores of Russia and Siberia, Willoughby, in 1553, discovered Nova Zembla, and forty years later Barentz explored Spitzbergen. Other voyages were made by Bering, Chelyuskin, and Liakov. In 1607 Hudson, the most daring and enterprising of Arctic explorers, reached a northern latitude of $80^{\circ} 23'$, a feat in which he was not surpassed for nearly two hundred years.

The first successful attempt to find this passage was made by Nordenskjöld. In 1878, after two years' battling with the ice, Nordenskjöld made his way eastward around the northern shores of Russia and Siberia. He entered the Arctic Ocean off the coast of Norway, and came out through Bering Strait into the Pacific Ocean.

Polar Expeditions.—In some of the most successful expeditions the chief object in view was to reach the north pole. In 1853 Kane, an American explorer, penetrated Kennedy Channel as far north as $81^{\circ} 27'$. The comparatively warm water and abundance of life led him to believe in the existence of an open polar sea. The discovery of Kennedy Channel was the most important result of this expedition.

Seven years later Hayes, who had been with Kane on his expedition in 1853, succeeded in reaching as far as $81^{\circ} 35'$ during a sledge journey through Grinnell Land. Hayes visited the open sea sighted by the officers of Kane's expedition, but it was then filled with ice.

In 1871 Hall forced a passage through Kennedy Channel and entered Robeson Channel, reaching latitude $82^{\circ} 16'$. During a sledge journey made on a previous expedition Hall visited the place where a few of the bodies of men belonging to Franklin's party were buried.

In 1875 Markham and Nares passed through Robeson Channel and entered the Arctic Ocean. During the winter Markham and Parr advanced with sledges over the pack-ice, and reached latitude $83^{\circ} 20' 26''$. Five years later Leigh Smith, in a small steamer, discovered Franz Josef Land, but got no farther north.

One of the most unfortunate of the polar expeditions was that of the Jeannette, which entered Bering Strait in 1881. The vessel was nipped in the ice-pack near Wrangell Island, and after drifting for over a year was broken up. A part of the crew crossed to the Delta of the Lena River, where many of them perished. A few men, under Engineer Melville, were the only survivors.

International Circumpolar Explorations.—In 1880 a series of eleven circumpolar stations were organized by the exertions of Lieutenant Karl Weyprecht for the study of the physical and meteorological phenomena of the polar regions. Two stations were authorized by the United States, one at Point Barrow, Alaska, in charge of Lieutenant Ray, the other at Lady Franklin Bay, under Lieutenant (now General) Greely. In 1882 Lockwood and Brainard travelled one hundred and fifty miles along the northern shore of Greenland and reached latitude $83^{\circ} 24'$, the highest ever attained by man. The interior of Grant and Grinnell Lands was explored by Greely, and several ranges of mountains and a large glacial lake were discovered. Other sledge journeys were made by Dr. Pavy, the surgeon of the expedition. On the return the party was compelled to remain at Cape Sabine, and, the provisions becoming exhausted, all but seven of the party perished.

HEIGHTS OF THE PRINCIPAL MOUNTAINS, PEAKS, AND VOLCANOES IN THE WORLD.

NORTH AMERICA.			
Name.	Height in feet.	Range.	Country.
Mount St. Elias, I.	19,500.	Alaskan.	Alaska.
Orizaba.	17,379.	Sierra Madre.	Mexico.
Poconotepetl, I.	17,781.	Sierra Madre.	Mexico.
Iztaccihuatl, I.	17,077.	Sierra Madre.	Mexico.
Mount Hooker.	16,750.	Rocky.	Dom. of Canada.
Mount Brown.	16,000.	Rocky.	Dom. of Canada.
Mount Cook.	16,000.	Alaskan.	Alaska.
Mount Crillon.	15,900.	Alaskan.	Alaska.
Mount Fairweather.	15,500.	Alaskan.	Alaska.
Mount Whitney.	14,898.	Sierra Madre.	California.
Sierra Blanca Peak.	14,464.	Rocky.	Colorado.
Tacoma (Mt. Rainier).	14,444.	Cascade.	Washington.
Mount Shasta.	14,442.	Cascade.	California.
Long's Peak.	14,271.	Rocky.	Colorado.
Pike's Peak.	14,147.	Rocky.	Colorado.
Frémont's Peak.	13,570.	Rocky.	Wyoming.
Wrangell, I.	12,066.	Alaskan.	Alaska.
Sierra Madre.	12,000.		Mexico.
Mount Hood.	11,225.	Cascade.	Oregon.
Cibao Mountains.	8,600.	Haytian Range.	Haiti.
Blue Mountains.	8,184.		Jamaica.
Sierra del Cobre.	7,200.		Cuba.
Mount Mitchell.	6,711.	Alleghany.	North Carolina.
Mount Washington.	6,288.	White.	New Hampshire.
Mount Marcy.	5,344.	Adirondack.	New York.
Jorullo, I.	4,265.	Sierra Madre.	Mexico.

SOUTH AMERICA.

Aconcagua, I.	23,910.	Andes.	Chili.
Tupungato, I.	22,016.	Andes.	Chili.
Gualatieri.	22,000.	Andes.	Chili.
Sorata, I.	21,400.	Andes.	Bolivia.
Illimani.	21,149.	Andes.	Bolivia.
Chimborazo, I.	20,703.	Andes.	Ecuador.
Arequipa, I.	20,320.	Andes.	Peru.
Cotopaxi, I.	19,498.	Andes.	Ecuador.
Tolima.	18,321.	Andes.	U. S. of Colombia.
Santa Martha.	16,728.	Northern Coast.	U. S. of Colombia.
Pichincha, I.	15,922.	Andes.	Ecuador.
Potosi.	15,377.	Andes.	Bolivia.
Roraima.	7,874.	Parime.	Venezuela.
Itacolumi.	5,740.	Brazilian Coast.	Brazil.
Itambe.	4,300.	Brazilian Coast.	Brazil.

EUROPE.

Elbrooz.	18,537.	Caucasus.	Russia.
Mont Blanc.	15,780.	Alps.	France.
Monte Rosa.	15,217.	Alps.	Italy.
Mount Mulhacen.	11,663.	Pyrenees.	Spain.
Mount Maladetta.	11,168.	Sierra Nevada.	Spain.
Mount Etna, I.	10,871.		Sicily.
Mount Olympus.	9,759.	Pinus.	Turkey.
Mount Rotondo.	8,838.	Sardo-Corsican.	Corsica.
Kriwan.	8,029.	Tatra.	Austria.
Ymesfield.	8,543.	Kiölen.	Norway.
Mount Sneehatten.	7,570.	Kiölen.	Norway.
Ben Nevis.	4,405.	Grampian.	Scotland.
Vesuvius, I.	4,163.		Italy.
Mount Snowdon.	3,589.	Welsh.	Wales.
Grampian Hills.	3,500.		Scotland.
Sea Fell.	3,228.		England.
Stromboli, I.	3,090.		Lipari Isles.

ASIA.

Mount Everest.	29,002.	Himalaya.	India.
Dapsang.	28,278.	Himalaya.	Thibet.
Kunchinjunga.	28,156.	Himalaya.	India.
Nanda Dewi.	25,661.	Himalaya.	India.
Demavend Peak.	20,112.	Elborz.	Persia.
Koosh Peak.	18,000.	Hindoo Koosh.	Afghanistan.
Kuen Lun Peak.	18,000.	Kuen Lun.	Thibet.
Ararat.	16,069.	Taurus.	Turkey.
Jebel-Makmel Peak.	12,182.	Lebanon.	Syria.
Mount Sinai.	9,302.		Arabia.
Mount Hermon.	8,740.	Asia Minor.	Palestine.

AFRICA.

Kilima Njaro.	18,700.		East Coast.
Kenia.	18,045.		East Coast.
Ras Detschen Peak.	15,158.		Abyssinia.
Cameroons.	14,000.	Guinea System.	Lower Guinea.
Jebel Tedla.	13,000.	Atlas.	Morocco.
Madagascar System.	12,000.		Madagascar Island.
Peak of Teneriffe, I.	12,000.		Island Teneriffe.
Mount Mitsin.	11,400.	Atlas.	Morocco.
Snow Mountains.	10,000.	Cape System.	Cape Colony.
Peak of Pico.	7,013.		Island Azores.
Kong.	3,000.		Soudan.

OCEANIA.

Singalang, I.	15,000.		Sumatra.
Mauna Loa, I.	13,760.		Sandwich Islands.
Kini Balu.	13,694.		Borneo.
Owen Stanley.	13,205.		New Guinea.
Mount Cook.	12,349.		New Zealand.
Tombooro, I.	7,000.		Sumbawa I.
Mount Kosciusko.	7,176.		Australia.
Mount Kilauea, I.	3,970.		Hawaii.

THE PRINCIPAL RIVERS OF THE WORLD, THEIR SYSTEMS, LENGTHS, AREAS OF BASINS, AND MOUTHS.

ARCTIC SYSTEM.			
River.	Length.	Area of Basin.	Mouth.
Mackenzie.	2,300.	441,600.	Arctic Ocean.
Great Fish.	900.		Arctic Ocean.
Obi.	2,700.	924,800.	Gulf of Obi.
Yenisei.	2,300.	784,000.	Yenisei Gulf.
Lena.	2,600.	594,000.	Arctic Ocean.
Dwina.	700.	142,000.	White Sea.

ATLANTIC SYSTEM.			
Saskatchewan and Nelson.	1,800.	360,000.	Hudson Bay.
Churchill.	1,000.	74,000.	Hudson Bay.
St. Lawrence.	2,200.	297,600.	Gulf of St. Lawrence.
Mississippi (with Missouri).	4,200.	982,400.	Gulf of Mexico.
Rio Grande.	1,800.	180,000.	Gulf of Mexico.
Orinoco.	1,500.	297,000.	Atlantic Ocean.
Amazon.	4,000.	1,512,000.	Atlantic Ocean.
Para and Tocantins.	1,300.	388,000.	Atlantic Ocean.
San Francisco.	1,400.	187,200.	Atlantic Ocean.
La Plata.	2,250.	586,400.	Atlantic Ocean.
Vistula.	600.	56,600.	Gulf of Dantzie.
Elbe.	684.	41,900.	North Sea.
Rhine.	950.	65,300.	North Sea.
Thames.	250.	6,100.	North Sea.
Seine.	500.	22,620.	English Channel.
Rhone.	550.	33,000.	Mediterranean Sea.
Danube.	1,000.	234,000.	Black Sea.
Dnieper.	1,200.	169,700.	Black Sea.
Don.	1,300.	168,400.	Sea of Azof.
Nile.	3,000.	520,200.	Mediterranean Sea.
Niger.	3,000.	600,000.	Gulf of Guinea.
Congo.	3,000.		Atlantic Ocean.

PACIFIC SYSTEM.			
Yukon.	2,010.		Norton Sound.
Columbia.	1,300.	191,000.	Pacific Ocean.
Colorado.	1,100.	170,000.	Gulf of California.
Amoor.	2,600.	582,800.	Sea of Ochotsk.
Hoang-Ho.	2,700.	537,400.	Eastern Sea.
Yang-tse-Kiang.	3,300.	547,800.	Eastern Sea.
Mekong.	2,000.	216,000.	China Sea.

INDIAN SYSTEM.			
Euphrates.	1,800.	unitedly }	Persian Gulf.
Tigris.	1,150.	195,000 }	Euphrates.
Indus.	1,800.	312,000 }	Arabian Sea.
Ganges.	1,800.	unitedly }	Bay of Bengal.
Brahmaputra.	2,000.	432,480 }	Bay of Bengal.
Irrawaddy.	1,200.	331,200 }	Bay of Bengal.
Zambezi.	1,800.	432,000 }	Mozambique Channel.
Murray.			Indian Ocean.

CONTINENTAL SYSTEMS.			
Humboldt.	350.		Humboldt L., Nevada.
Volga.	2,200.	397,500.	Caspian Sea.
Ural.	1,000.	53,200.	Caspian Sea.
Syr (Silon).	990.	unitedly }	Aral Sea.
Amoo (Oxus).	900.	431,900 }	Aral Sea.

ELEVATION OF THE IMPORTANT PLATEAUS OF THE WORLD.

PLATEAUS OF NORTH AMERICA.			
Eastern Plateau of the Rocky Mountains.	2,000 to 6,000		
Great Western Plateau.			
Great Interior Basin.	4,000 to 5,000		
Northern.	3,000 to 4,000		
Southern.	3,000 to 7,500		
Mexican Plateaus.			
Toluca.	8,500		
Anahuac.	6,000 to 8,000		
Central American Plateaus.			
Guatemala.	5,000		
Costa Rica.	5,000		
PLATEAUS OF SOUTH AMERICA.			
Colombia.	8,700		
Popayan.	5,700		
Ecuador.	10,000		
Peru and Bolivia.	12,000		
Brazil.	3,200		

PLATEAUS OF EUROPE.			
Spanish Peninsula.	2,000 to 3,000		
Auvergne, France.	1,087		
Bavaria.	1,663		

PLATEAUS OF ASIA.			
Thibet.	12,000 to 17,000		
Arabia.	5,000 to 8,000		
Asia Minor and Armenia.	2,800 to 3,500		
Gobi.	2,400 to 6,000		
Persia.	2,000 to 3,500		
The Deccan.	1,500 to 2,000		

PLATEAUS OF AFRICA.			
Abyssinia.	7,000 to 8,000		
South Africa.	2,400 to 5,000		

AREAS, ELEVATIONS, AND DEPTHS OF PRINCIPAL LAKES.			
Lake.	Area.	Elevation, ft.	Depth, ft.
Caspian Sea.	145,000.	—80.	2,800
Aral Sea.	30,000.	50.	
Lake Baikal.	14,000.	1,800.	500
Sir-i-Kol.	41.	15,600.	
Dead Sea.	320.	—1,302.	700
Lake Superior.	31,500.	627.	1,008
Lake Michigan.	23,150.	595.	870
Lake Huron.	23,100.	555.	702
Lake Erie.	7,800.	500.	120
Lake Ontario.	6,900.	200.	734
Great Salt Lake.	2,000.	4,200.	
Lake Winnipeg.	9,000.	628.	
Lake Chapala.	1,000.	7,000.	
Lake Nicaragua.	3,500.	130.	
Lake Titicaca.	4,000.	12,847.	
Lake Ladoga.	6,190.		
Lake Victoria.	34,000.	3,308.	
Lake Albert.		2,720.	

PRINCIPAL PLAINS OF THE WORLD.			
NORTH AMERICA.			
Great Central Plain.			
Atlantic Plain.			
SOUTH AMERICA.			
Llanos of the Orinoco.			
Silvas of the Amazon.			
Pampas of La Plata.			
EUROPE.			
Great Northern Plain.			
Plain of Lombardy.			
ASIA.			
Siberian Steppes.			
Lowlands of China.			
Plains of Farther India.			
Plain of Hindoostan.			
AFRICA.			
The Sahara.			

PRONOUNCING VOCABULARY

OF

GEOGRAPHICAL AND OTHER PROPER NAMES.

In this Vocabulary, *ä* represents the sound of *a* in palm; *ä* that of *a* in fate; *ä*, *a* in fat; *ä*, *e* in met; *i*, *i* in pine; *i*, *i* in pin; *ö*, *o* in mode; *ö*, *o* in not; *öö*, *oo* in moon; *öö*, *oo* in wood; *öw*, *ow* in now; *ü*, *u* in music; *ü*, *u* in run; *gh*, *g* in get; *ñ*, *ny* in banyan; *ſ*, *s* in won't; *th* (*italic*), *th* in then; *th*, *th* in thin; *u*, prolonged sound of *u* in thus; *ö*, almost like *e* in her; *ü*, the French *u*, and German *ü*, a sound between that of *ee* and that of *oo*; *ſſ*, the French nasal sound, somewhat like that of *ny* sounded through the nose; *ñ*, the Spanish sound of *d*, almost like *dth* in breadth. The last four sounds can be properly communicated only by an oral instructor. The pronunciations are based upon the Pronouncing Gazetteer of Worcester's Dictionary, edition of 1857.

A.

Abyssinia, äb is sin'e ä.
Acaray, äh kä rî.
Acilla, ä söl'lä.
Acelopan, äk lö pän'.
Acconeagua, ä kon kä'gwä.
Adansonia, äd an so'ne ä.
Adelsberg, ä'dels bërg.
Adelung, ä'dä lööng.
Adirondack, äd e ron'dak.
Aeronaut, ä'er o nawt.
Agassiz, äg'ä se.
Aguachapa, ä gwä chä'pä.
Agulhas, ä gool'yäs.
Air, ä eer'.
Ala Tagh, ä'lä täg.
Albert Nyanza, n'yän'zä.
Aleutian, ä loo'she an.
Aliaska, ä lë äs'kä.
Alleghany, or Allegheny, äle gä'ne.
Almaden, älä mädän'.
Altai, älä tî.
Altamaha, äwl tä mä haw'.
Altyn Kool, älä tin' kool.
Aluminium, älä min'tum.
Amargosa, ä mar gö'sä.
Amoo' Dar'ya.
Anahuac, ä nä wäk'.
Andaman, ädä man'.
Anthelia, änt heel'yä.
Antigua, änt tēgä.
Apennines, äp'en nīnz'.
Appalach'ian, or ap pä lä'che an.
Apure, ä poo'rä.
Apuimac, ä poo rē mäk'.
Aquila, ä'kwē lä.
Arabie, ä'rä bik.
Arago, ä'rä go.
Ararat, ä'rä rat.
Archipelago, äk pel'ä go.
Arica, ä rē'kä.
Ariesian, ä rēez'yan.
Artois, ärtwä'.
Aryan, äryan.
Assam, äs säm'.
Assyrian, äs sir'e an.
Astrakhan, äs trä kän'.
Astrapée, äs trä'pē e.
Atacama, ä tä kä'mä.
Atchafalaya, ätch ä lä h'ä.
Athabasca, äth ä bas'kä.
Atoll, ä töl'.
Audubon, äw'doo bon.
Aurora Borealis, äw ro'rä bo rē ä'lis.
Auvergne, ö väirn'.
Avalanche, äv ä lānsh'.
Azores, ä zör'z.

B.

Bagnes, bäñ.
Bahr As'sal.
Baikal, bä'käl.
Bakou, bä koo'.
Balcash, bälä käsh'.
Bald Yökul, bält yök'ööl.
Bali, bäle.

Balkan, bäl'kän.
Banea, bang'kä.
Baraba, bä rä bä'.
Basaltic, bä sawl'tik.
Basques, bäsks.
Batrachians, bä trā'kē anz.
Bechuanas, bët choo ä'naz.
Bel'ed el Jerid, jër jēd'.
Belleisle, bël lile'.
Beluga, bë loo'gä.
Bemal, bën gaw'.
Ben Nevis, bën nevis.
Beni, bë ne'.
Bergen, bërg'en.
Bergschrund, bërg'shröünd.
Bilin, bë leen'.
Blumenbach, bloo'men bäk.
Bogosloff, bö gös löf'.
Bogota, bö go tä'.
Bolivia, bö līv'e ä.
Bonifacio, bö ne fä'cho.
Bonin, bö neen'.
Bonpland, böng plöng'.
Bootan, boo tän'.
Bornou, bor noo'.
Brahmaputra, brä mä poo'trä.
Buenos Ayres, bö'nos ä'ríz.
Burekhardt, burk'hart.
Bushire, boo sheer'.

C.

Cabul, kä bool', or kaw' b'l.
Callao, kälä lö', or kälä yä'ö.
Cameroons, käm er öönz'.
Campagna, käm pä'n'yä.
Canaveral, kä näv'er al.
Cañon, känyön.
Cantabrian, kä tä'bre an.
Capellan, kä pel län'.
Caracas, kä rä'käs.
Caribbee' an.
Caribs, kä'rībz.
Carnivora, kä nīv'o rä.
Caroline, kä'rö līn.
Carran Tual, kä'rān too'al.
Carthago, kä tä'go.
Casamicciola, kä sä mīt chö'lä.
Casiquiare, kä se ke ä'rä.
Caucasian, käw kä'she an.
Caucasus, käw'kä sus.
Caxamarca, kä hä mar'kä.
Ceuta, soo'tä.
Cévennes, sä vën'.
Chagos, chä'gös.
Chamouni, shä moo ne'.
Chandeleur, shän chē loor'.
Chapala, chä pä'lä. [plönxh'.
Chapelle-aux-Planches, shä pel'ö
Charlemagne, shär lē män'.
Charybdis, kä rīb'dis.
Cheduba, chē doo'bä.
Cheltenham, chelt'näm.
Chelyuskin, chel yös'kin.
Cherokee, chör ro kē'.
Cherrapongî, chër rä pon jē'.
Chignecto, shig nek'to.

Chihuahua, chö wä'wa.
Chili, chil'le.
Chimborazo, chīm bö rä'zo.
Chinook, chī nöök'.
Chittagong, chīt tā gong'.
Choco, cho'ko.
Chollar, chöl'lär.
Chota, cho'tä.
Chiao, se hä'ö.
Circassian, sir kash'yän.
Cirrus, sir'rus.
Cleopatra, klē o pat'rä.
Com'orin.
Concepcion, kon sep se ön'.
Conchas, kon'chas.
Constantina, kon stan tō'nä.
Copernicus, ko per'ne kus.
Copiapo, ko pe ä po'.
Coringa, ko ring'gä.
Corona, ko ro'nä.
Costa Rica, kös'tä re'kä.
Cot'dal.
Cotopaxi, ko to pax'e.
Creuzot, kruh zö'.
Crevasse, krē väs'.
Criba, kre'bä.
Cumana, koo mä nä'.
Cumulus, kä'mü lös.
Cuvier, kü ve ay', or kü've er.
Cuzco, köös'ko.
Cyclades, sīk'lä deez.
Cyclone, sīklön.
Cyclopean, si klöp'e an.

D.

Damara, dä mä'rä.
Dariel, dä re el'.
Deccan, dēk'kan.
Del Cane, del kä'nä.
Demavend, dem ä vend'.
Demerara, dem er ä'rä.
Desaguadero, dēs ä gwä pä'ro.
De Saussure, dēh so soor'.
Des Bois, dä bwä'.
Des Demoiselles, dä dem wä zēl'.
Despoblado, dēs po blä'do.
Dnieper, nē'per.
Dniester, nē'ster.
Dos Palmas, dös päl'mäs.
Dovrefield, dö'vrēh fyēld. [veel'.
Dumont d'Urville, dü möng' door
Dureas, doo ray ah'.
Dwina, dwī'nä, or dwe'nä.

E.

Echinus, e kī'nus.
Ecuador, ek wä dore'.
Ehrenberg, ä'ren bërg.
El Altar, el älä tar'.
Elborz, el borz'.
El'brooz.
El Gran Chaco, el grän chä'ko.
El Llano Estacado, el l'yä'no es tä
kä'do.
Entre Rios, en'trä re'ös.

Erebus, ér'e bus.
Esquimaux, es'ke mo.
Etesian, e teez'yan.
Euphrates, ü frä'teez.
Everest, ev'er est.

F.

Fahrenheit, fär'en hite.
Falkland, fawk'land.
Faroe, fär'o.
Fata Morgana, fä'tä mor gä'nä.
Fayal, fi älä'.
Fingal, fīn'gawl.
Florida, flör'tä dä.
Foucault, foo kö'.
Fournel, foor nel'.
Frederickshall, frēd'er iks hä.

G.

Gaelic, gä'lik.
Gallenreuth, gh'en roit.
Galapagos, gä lä'pä gös.
Gallas, gäl'läz.
Galveston, gäl'vēs tön.
Garonne, gä ron'.
Gay-Lussac, gä lös säk'.
Gennao, jen nä'e.
Genoa, jen'o ä.
Géral, zhä rä'l'.
Gescke, gä zek'eh.
Geyser, ghī'ser.
Ghauts, gawts.
Ghe'bers.
Gila, he'lä.
Gihlo, he lö'lo.
Glacier, glä'seer, or glas'e er.
Gneiss, nice.
Goleonda, gol kon'dä.
Greenwich, grīn'tj.
Grenelle, grēh nel'.
Grisons, grē zōng'.
Grudéitz, gröö dä'tis.
Guadeloupe, gwä dēh loop'.
Gualateiri, gwä lä tä e rē'.
Guanaxuato, gwä nä hwä'to.
Guardafui, gwär dä fwe'.
Guatemala, gwä tä mä'lä.
Gukana, ghe ä'nä.

H.

Hemus, he'mus.
Han-Hai, hän hī'.
Harmattan, har mat'tan.
Hartz, harts.
Hawaii, hä wī'e.
Hayti, hä'te.
Hebrides, hēb'rid eez.
Herat, her ät'.
Herauld, ä rō'.
Herculeaneum, her kü lä'ne üm.
Hercules, her'kü leez.
Herschel, her'shel.
Hierapolis, hi e rap'ö lls.
Himalaya, him ä' lē ä.
Hin'doo Koosh.

Hinter Rhin, hin'ter rin.
Hoang-Ho, ho ang ho'.
Hoehow, ho chōw'.
Hogolen, o go luh'.
Holywell, hō'le wel.
Honda, ōn'dā.
Hotham, hō tham.
Houssan, hōw sän'.
Huancavelica, wän kä vä'le kä.
Huantajaya, wän tä h'ä.
Hungary, hung'gä re.
Huzareh, huz'ah reh.
Hyderabad, hi der ä bäd'.
Hygrometer, hi grom'e ter.

I.

Ieononza, e ko non'zä.
Ignis-Fatuus, ig'nis fat'yoo us.
Illimani, eel yē mä'nē.
In-Shan, in shän'.
Irkoosk'.
Irrawaddy, ir rä wod'de.
Irtysh, ir tish'.
Ischia, is'ke ä.
Ishim, ish eem'.
Isothermal, i so ther'mal.
Issi Kul, isse kool'.
Itabira, e tä be'rä.
Itacolmi, e tä ko loo me'.
Itambe, e täm'bä.
Itasca, i tas'kä.
Iztaccihuatl, ees täk se hwät'l.

J.

Jalapa, hä lä'pä.
Jan Mayen, yän m'ien.
Java, jä'vä.
Jebel Tedla, jeb'el ted'lä.
Jorullo, ho rool'yo.
Jungfrau, yöng'fröw.

K.

Kabyles, kä'beelz.
Kadiak, käd yak'.
Kaemtz, kemts.
Kalahari, kä lä hä're.
Kalmuiks, kä'l'muks.
Kamchatka, käm chät'kä.
Kanawha, ka naw'wä.
Kasem, kä seem'.
Katahdin.
Kenia, kä nē'ä.
Kentei-Khan, ken tä kän'.
Kerguelen, kerg'e len.
Khamzin, käm'zin.
Kilauea, ke löw ä'ä.
Kilima Njaro, ke'le mä n'jä'rö.
Kiölen, ke ö'len.
Kirguis, kir ghee'z'.
Klam'ath.
Koo'ril.
Kosciusko, kos se us'ko.
Kotzebue, köt'se bü.
Krakatoa, krä kä tö'ä.
Kuen Lun, kwen loon'.
Küloch, kü'lok.
Kur, koor.
Kurdistan, koor dis tä'n'.
Kuro Siwo, koo'ro se'wo.
Kuttenberg, kut'ten bērg.

L.

Laccadive, läk'ä dive.
La Chine, lah sheen'.
Ladoga, läd'o gö.
La Merced, lä mēr säd'.
Langfield, läng' f'yēld.
La Paz, lä pä's'.
La Plata, lä plä'tä.
Leeuwin, le'win.
Le Maire, leh mair'.

Levant, le vant'.
Lima, le'mä.
Lipari, lip'ä re.
Lithuania, lith öö ä' nē ä.
Llama, lä'mä.
Llanos, l'yä'nös.
Logodoën, log o dö'en.
Loo-Choo', or Liu Kiu'.
Los Angeles, lös äng'hä lēs.
Lupata, loo pä'tä.
Luxan, loo hän'.

M.

Maca, mä'kä.
Macao, mä köw'.
Macquarie, mä kwör're.
Madeira, mä dä'e rä.
Maelstrom, mä'l'sträm.
Mag'dalen, or möd'län.
Magellan, mä jel'lan.
Magyar, mod yor'.
Mahabeshwar, mä hä biēsh wur'.
Mahratta, mä rat'tä.
Malacca, mä lak'kä.
Maladetta, mä lä det'tä.
Malay, mä lä'.
Maldiva, mal'dive.
Malwa, maw'wä.
Manasarowar, mä nä sä ro wär'.
Manco Capac, män ko kä päk'.
Mantchooria, man choo're ä.
Maracaybo, mä rä k'bo.
Maranhau, mar an ham'.
Mar Jirius, mar j'i'ri üs.
Marmora, mar'mo rä.
Marquesas, mar kä'säs.
Martinique, mar tin eek'.
Massuah, mä's'söö ä.
Matagorda, mat ä gor'dä.
Matto Grosso, mä'to gros'so.
Mauna Loa, möw'nä lö'ä.
Mauritia, maw rish'e ä.
Mauritius, maw rish'e us.
Maypu, mä'poo'.
Medina, me dē'nä.
Mediterranean, med i ter rä'nē an.
Meinan, mä e nām'.
Mendocino, men do se'no.
Merced, mer säd'.
Mer de Glace, mair deh gläs'.
Mesopotamia, mes o po tä'mē ä.
Messina, mēs sē'nä.
Metamorphic, met ä mor'fik.
Meteorite, me'te o rite.
Meyen, m'ien.
Michigan, mish'e gan.
Mikra Kameni, mik'rä kä mä'ne.
Mil'an.

Minnehaha, min ne hä'hä.
Mirage, me räzh'.
Mistral, mēs'trawl.
Mocambe, mö käm'bä.
Moluccas, mö lük az.
Monsoon, mon soon'.
Mont Blanc, möng bläng'.
Monte Furca, mon'tä föor'kä.
Monterey, mon tä rä'.
Monte Rosa, mon'tä ro'sä.
Monte Rotondo, mon'tä ro ton'do.
Moraine, mo rän'.
Moskoë, mos'ko ēh.
Moussim, moo'sim.
Mozambique, mo zam beek'.
Mulahacen, moo lä ä then'.
Mysore, mi sore'.

N.

Nahr el Leben, nar el lä ben'.
Nanda Dewi, nän'dä dä've.
Nea Kameni, nä'ä kä mä'nē.
Nebel el Fuar, nay bär' el föo ar'.
Nedsjed, ned'jed.
Neilgherries, neel ghēr'reez.

Nemi, nä'me.
Nepaul, ne pawl'.
Nevada de Huila, nä vä'dä dä wē'lä.
Newfoundland, nä'fund land.
Ngami, n'gä'me.
Nicaragua, nik ä rä'gwä.
Nicobar, nik o bar'.
Nicot, nē ko'.
Niemen, ne'men.
Niger, nī'jer.
Niti, nē'tē.
Norwich, nör'ij.
Notre Dame, nōt'r dä'm'.
Nueces, nwä'sēs.
Nunivak, noo ne väk'.
Nyanza, n'yän'zä.
Nyassi, n'yäs'se.

O.

Oases, o'ä secz, or o ä'secz.
Oaxaca, wä hä'kä.
Oberstein, o'ber stine.
Obi, o'bē.
Ogechee, o ghe'che.
Ohlsen, ö'l'sen.
Okhotsk, o kotsk'.
Olafsen, ö'läf sen.
Olosenga, o lo seng'gä.
Oneida, o nī'dä.
Oppido, öp'pe do.
Osteolopis, os te o lö'pis.
Ostia, ö'ste ä.

P.

Pacaraima, pä kä rī'mä.
Paderborn, pä'der born.
Padre, pä'brä.
Palaia Kameni, pä l'ä kä mä'ne.
Palgrave, pawl'grave.
Pallah, pä'lä.
Pamir, pä meer'.
Pamlico, pam'le ko.
Pamperos, pä'm pä'rös.
Panama, pä'n ä mä'.
Pandanus, pan dan'us.
Papua, pä pöö'ä.
Paramaribo, par ä märe'bo.
Parana, pä rä nä'.
Paraselenae, pä ä se le'ne.
Parhelia, pä'r heel'yä.
Parime, pä rē'mä.
Paros, pä'rös.
Passamaquoddy, pas sä mä kwod'de.
Paumotu, päw mö'töö.
Pecos, pä'kös.
Pele, pä'lä.
Pen'bina.
Penrhyn, pen'rīn.
Pentelienus, pen tel'e kūs.
Peshan, pä shän'.
Pillares, pe lä'rēs.
Plateau, plä to'.
Platinum, plät'in üm.
Polynesia, pol e nē'she ä.
Pompeii, poni pä'e.
Pontchartrain, pont shar train'.
Popayan, po pi än'.
Popocatepetl, po po kä tä pet'l'.
Potosi, po to se'.
Prairies, prä'rīz.
Procida, prä'chē dä.
Pro'te us.
Prypet, pri'pet.
Puebla, pwēb lä.
Puget, pū'jet.
Pumachanche, poo mä chän'chä.
Pumice, pum'is.
Puna, poo'nä.
Punjaub, pun jawb'.
Purace, poo rä sä'.
Pusztä, pöös'töh.
Puzzuoli, pööt söö ö'lē.
Pyrenees, pī'en eez.
Pymont, peer'mont.

Q.

Quijota, kē hō'tä.
Quito, ke'to.

R.

Ramree, räm re'.
Ras Detschen, räs det'shen.
Reggio, red'jo.
Reikianaes, rī'ke ä nes.
Rewan, rä' wan.
Richelieu, re sheh lū'.
Riobamba, re o bäm'bä.
Rio Grande, re'o grän'dä.
Rio Negro, rē'o nä'gro.
Rio Virgen, re'o veer'hen.
Roraima, ro rī'mä.
Rotomahana, ro to mä hä'nä.
Ruera, röo ä rä'.
Ruska Poyana, röös'kä po yä'nä.

S.

Sabine, sä been'.
Sacramento, sak rä men'to.
Saguenay, säg ä nä'.
Sahara, sä hä'rä.
Sala y Gomez, sä'lä ē go meth'.
Saltillo, sä'l teel'yo.
Samen, sä'men.
Samoiedes, sam oy edz'.
San Diego, sän dē ä'gō.
San Felipe, sän fä lē'pä.
Sangar, sän gar'.
Sangay, sän ghī'.
San Joaquin, sän wä keen'.
San José, sän ho sä'.
Santa Ana, sän tä'nä.
Santa Barbara, sän'tä bar'bä rä.
Santa Fé, sän'tä fä'.
Santa Maria, sän'tä mä re'ä.
Santorini, sän to re'ne.
Sar'do-Corsican.
Saskatchewan, sas katch'ē wön.
Satpoora, sä't poo'rä.
Saut, sö.
Sea Fell, skaw' fel.
Selavonic, slä von'ik.
Scandinavian, skan de nä've an.
Schams, shämz.
Schotte, shöt.
Sciaccia, shäk'kä.
Scythian, sith'e an.
Semitic, se mit'ik.
Seringapatam, ser ing gä pä tam'.
Shamo, shä'mo.
Siam, si am'.
Sicily.
Sierra Blanca, se ē'rä bläng'kä.
Sierra del Cobre, se ē'rä del kö'brä.
Sierra Leone, se ē'rä le ö'nē.
Sierra Madre, se ē'rä mä'drä.
Sierra Morena, se ē'rä mö rä'nä.
Sierra Nevada, se ē'rä nä vä'dä.
Sihon, si hoon'.
Silesia, si le'she ä.
Sil'vas.
Simoda, se mö'dä.
Simoom, se moot'm'.
Sir i Kol, sir e kol'.
Sir Dar'ya.
Sirocco, se rok'ko.
Sitka, sit'kä.
Skaptar Jökul, skäp'tar yö'kööl.
Sneehätten, snä'het ten.
Solano, so lä'no.
Solfatara, sol fä tä'rä.
Sorata, so rä'tä.
Soudan, söö dän'.
Souffrière, söö fre air'.
Spa, spä.
Stalactite, stä lak'tite.
Stalagmite, stä lag'mite.
Stanovoi, stä no voy'.
St. Croix, sent kro'i'.
Steppes, steps.

St. Augustine, sent awg'ús tēen.
 St. Gothard, sent got'hart.
 St. Michael, sent mī'kēl.
 Strata, strā'tā.
 Stratus, strā'tūs.
 Stromboli, strom'bo le.
 St. Roque, sent rōk.
 Suadiva, soo ñ de'vā.
 Sudetic, soo det'ik.
 Suliman, soo le mán'.
 Sumach, soo'mak.
 Sumbawa, sōm baw'wā.
 Sumburgh, sum'būr rūh.
 Summa Paz, soom'mā pás.
 Sutlege, sut'lej.
 Swansea, swon'se.
 Syriac, sir'e āk.

T.

Tacazze, tā kāt'sā.
 Tahiti, tā hē'tē.
 Tahoe, tā hō'.
 Tanchi-Boulac, tām che boo lak'.
 Tanganyika, tām gām yē'kū.
 Tangnou, tām noo'.
 Tapaling, tā pā ling'.
 Taranta, tā ran'tā.
 Tarawera, tā rā wā'rā.
 Tarbagatai, tar bā gā tī'.
 Tarifa, tā re'fā.
 Tasmania, tās mā'nē ā.
 Talra, tā'lri.
 Tau, tōw.
 Tehad, chād.
 Tehuantepec, tā wān tā pek'.
 Tenasserim, ten as'sēh rim.

Teneriffe, ten er id'.
 Tenochtitlan, tā nok tit lan'.
 Tequendama, tā ken da'ma.
 Terek, tā rek'.
 Terra del Fuego, tēr'ra del fōō ā'gō.
 Terremotos, tēr rā mo'tōs.
 Tertiary, tēr'she ā re.
 Teutonic, too ton'ik.
 Thames, tēmz.
 Thian Shan, te an' shan.
 Thibet, tib'et.
 Thom, tom.
 Thian Shan, te an' shan.
 Tibbet, tib'et.
 Tibboos, tib booz'. [tēs.
 Tierras Calientes, te ér'rās kal yēu'
 Tierras Frias, te ér'rās frē'ās.
 Tierras Templadas, te ér'rās tem
 pla'das.
 Tigris.
 Tifeneia, te te kā'kā.
 Tocantins, to kām teens'.
 To'kio.
 Tolima, to le'mā.
 Toluca, to loo'kā.
 Tomboro, tom bō'rō.
 Torghatten, torghet ten.
 Torre del Greco, tor'rā del grā'ko.
 Torricelli, tor rē chēllē.
 Trieste, trē est'.
 Tripoli, trip'o lē. [yā.
 Tristan d'Acunha, trēs tām'da koon'
 Trivandrum, trē vān'drum.
 Trondjem, trōnd'yem.
 Tsiutung, tse en tung'.
 Tueson, too sōn'.
 Tulza, tul'zā.
 Tunca, tung'kā.
 Tundra, toon'drā.

Tunguragua, tōōng gōō rā'gwa.
 Tungusian, tōōng gōō'se an.
 Turanic, tū rān'ik.
 Turbaco, toor ba'ko.
 Typhoon, ti foon'.

U.

Ucayale, ōō kī ā'lā.
 Ulskoj, ōōd skoy'.
 Ulenborg, ōō'lā ō borg.
 Ullah Bund, ul'lā bund'.
 Umbagog, um bā'gog.
 Urumiyah, ōō rōō me'ā.

V.

Valais, vā lā'.
 Val Calanca, vāl kī lan'kā.
 Valdai, vāl dī'.
 Valparaiso, vāl pā ri'so.
 Vaseo da Gama, vās'ko da ga'ma.
 Vaseo Nuñez de Balboa, vās'ko
 noon'yeth de bal bō'ā.
 Velino, vā lē'no.
 Venezuela, ven ez we' la.
 Vent de bise, vōng deh bēz'.
 Vera Cruz, vā'rā krōōz.
 Veragua, vā ri' gwā.
 Verde, verd.
 Vesuvius, vē su'vī us.
 Via Mala, vē'ā mā'lā.
 Victoria Nyanza, n'yān' zā.
 Vignone, veen yo'nā.
 Vilini, vē le ōō'e.
 Vindhya, vind'yā.

Vistula, vis'tu lā.
 Vosges, vōzh.
 Vulcanos, vool ka'nōs.

W.

Wabash, waw'hāsh.
 Walferdin, wāl fair deen'.
 Wasatch, wā satch'.
 Wieliczka, wē lich'kā.
 Winnipeg, win'ne peg.
 Winnipissaukee, win ne pe saw'kē.
 Wot'chish.
 Wrangell, rang'el.
 Wul'er.

Y.

Yablonol, yā blo noy'.
 Yakootsk, yā kōōtsk'.
 Yangling'.
 Yang tse Kiang, yang tse ke ang'.
 Yazidees, yaz ē deez'.
 Ybera, ē bā'ra.
 Yenisel, yēn ē sē' ē.
 Ymesfield, y'mes f'yēld.
 Yosemite, yo sem'ē te.
 Yukon, yū'kon.
 Yu'mā.

Z.

Zagros, zā'grōs.
 Zaire, zā eer'.
 Zambezi, zām bā'ze.
 Zanzibar, zān zē bar'.
 Zúñi, zoon'ye.
 Zwellendam, zwel len dām'.

DERIVATION OF SOME OF THE MORE COMMON GEOGRAPHICAL TERMS.

AAR, AR, a river, or running water; as *Aar*, *Tamar*, *Arve*.
 AB, ACB, a river; as *Punjab*, the five rivers; *Abikuren*, the river of Cyrus.
 AGUA, AGOA, water; as *Agua Caliente*, hot water; *Aguapehi*, the river Pehi.
 ALP, ALB, a hill or mountain white with snow; as the *Alps*.
 ARROYO, a river; as *Arroyo Seco*, a dry river-bed.
 ATH, a ford; as *Athboy*, yellow ford; *Athlone*, ford of St. Luanus.
 AVON, flowing water; as *Avondale*, the valley of the river.
 BAB, gate; as *Bab el Mandeb*, the gate of tears.
 BAHR, a river; as *Bahr Assal*, the river Assal.
 BAHIA, a bay; as *Bahia Honda*, deep bay.
 BALI, BELT, a strait; as *Baltic Sea*, the sea of straits.
 BEN, PEN, VEN, a mountain; as *Ben Lomond*, beacon mountain; *Apennines*, *Cervines*.
 BERG, a mountain; as *Hörselberg*, Ursula's mountain.
 BY, a town; as *Rugby*, rock-town; *Kerby*, church-town.
 COMBE, CUMB, a valley; as *Wyecombe*, valley of the Wy River; *Cumberland*, land of valleys.
 COSTA, CÔTE, a coast; as *Costa Rica*, rich coast; *Côte d'Or*, coast of gold.
 DALE, THAL, a valley; as *Rosedale*, Rosenthal, valley of roses.
 DAM, a dike or dam; as *Amsterdam*, the dike of the Amstel.
 DARYA, a river; as *Sir Daryya*, Amoo *Daryya*.
 DIVE, an island; as *Maldives*, thousand islands; *Laccadives*, Lakara Islands.
 DON, DOWNS, DUN, a hill or fort; as *Abingdon*, the abbey on the hill; *South Downs*; *Dunkirk*, church on the hill.
 EY, an island; as *Anglesey*, island of the Angles; *Mersey*, island of the sea.
 FIELD, FJELD, a mountain; as *Dovrefield*, the mountain near Dovre.
 FIRTH, FJORD, FIUTH, a narrow body of water.
 FOLK, a people; as *Norfolk*, north people; *Suffolk*, south people.
 FORD, FURR, a ford; as *Oxford*, ford of the oxen; *Bradford*, broad ford; *Frankfort*, ford of the Franks.
 GAT, GATE, GUT, a strait, or narrow passage; as *Cattegat*, strait of the Catti; *Hellgate* (formerly *Horllgatt*), the whirlpool strait; the *Gut* or Strait of Canso.
 GUAD, WAD, a river; as *Guadalquivir*, or *Wad el Kebir*, the great river; *Wady Halfa*, the river Halfa.
 HO, a river; as Hoang *Ho*, Yellow River.

HONDO, deep; as *Rio Hondo*, deep river; *Bahia Honda*, deep bay.
 ILE, ISLE, INNIS, INCH, an island; as *Belisle*, beautiful island; *Innistory*, high island; *Lacheomb*, island of Columbia.
 KEN, KIN, a head, cape, or promontory; as *Kenmore*, great head; *Kinnaird*, head of the highlands.
 KIANG, a river; as *Yang tse Kiang*.
 LAC, LOCH, LOUGH, a lake; as *Fond du Lac*, end of the lake; *Mille Lacs*, thousand lakes; *Interlachen*, between lakes; *Lough Foyle*, etc.
 MERE, MER, the sea; as *Merton*, the town on the sea; *Mersey*, island of the sea.
 MONT, MONTE, a mountain; as *Beaumont*, *Belmont*, beautiful mountain; *Montreal*, King's Mountain; *Vermont*, Green Mountain.
 MULL, a headland; as the *Mull* of Kintyre.
 NANT, a brook; as *Nantes*; *Nanterre*, land of brooks.
 NASE, NAZE, NESS, a nose, cape, or headland; as the *Naze*; *Fifeness*, the promontory of Fife.
 NETHER, lower; as *Netherlands*, lower lands.
 NORD, NORTE, the north; as *Norfolk*, north folk; *Paso del Norte*, pass of the north.
 OST, east; as *Ostrom* (or *Ost-strom*), East River; *Österreich*, eastern kingdom.
 POINT, PUNTA, PUENTA, a headland or promontory; as *Point Judith*; *Punta Nueva*, new cape.
 PORT, PUERTO, a harbor; as *Portland*, *Bridgeport*; *Portugal*, harbor or landing-place of the Gauls.
 RID, a ridge; as *Rigby*, town on the ridge.
 RIO, a river; as *Rio Colorado*, Red River.
 ROSS, ROSE, a promontory; as *Kinross*, summit of the promontory; *Melrose*, naked promontory.
 SEE, ZEE, a lake or sea; as *Thuner See*, Lake Thun; *Zuider Zee*, South Sea; *Zealand*, land in the sea.
 STAN, land; as *Hindoostan*, land of the Hindoos; *Afghanistan*, land of the Afghans; *Paghestan*, land of mountains.
 STRÖM, a stream; as *Maelström*, the mill stream.
 TAG, TAGH, DAGH, a mountain; as *Allyn-tagh*, *Rilo-dagh*.
 TERRE, TERRA, land; as *Finisterre*, the land's end; *Mediterranean*, in the middle of the land.
 VAL, a valley; as *Transeal*, across the valley.

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